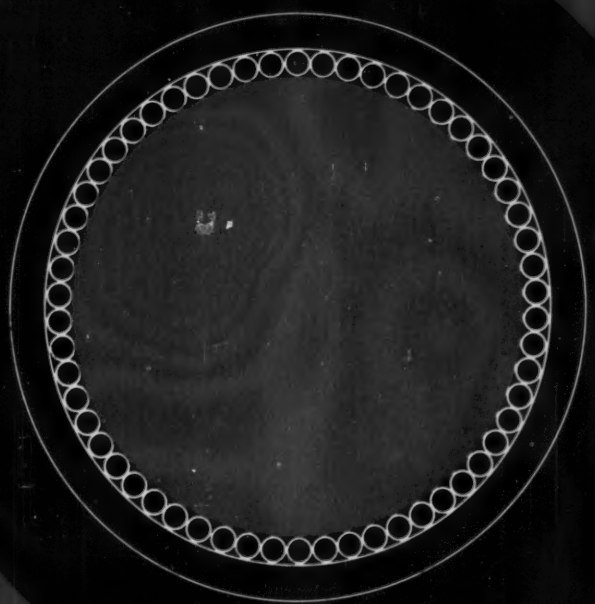
JULY 21, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



High-Load Oscillating Bearings

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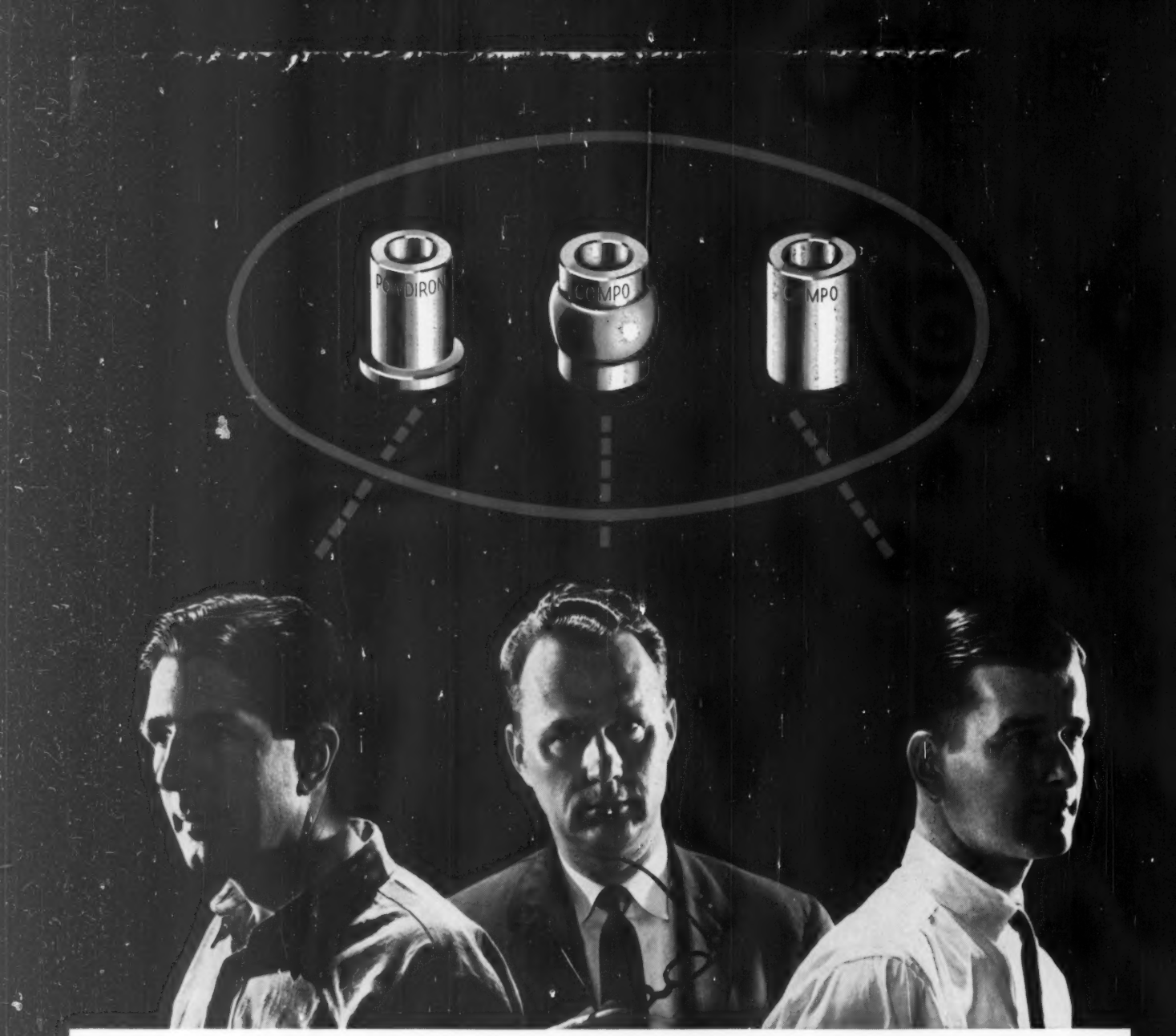

Specialization in bearings enables us to apply to your bearing problems an unmatched engineering talent and experience in powder metallurgy. You benefit, too, from outstanding manufacturing facilities, including the world's largest inventory of dies. Whatever your need, when it's bearings, see the bearing specialists... see Bound Brook.

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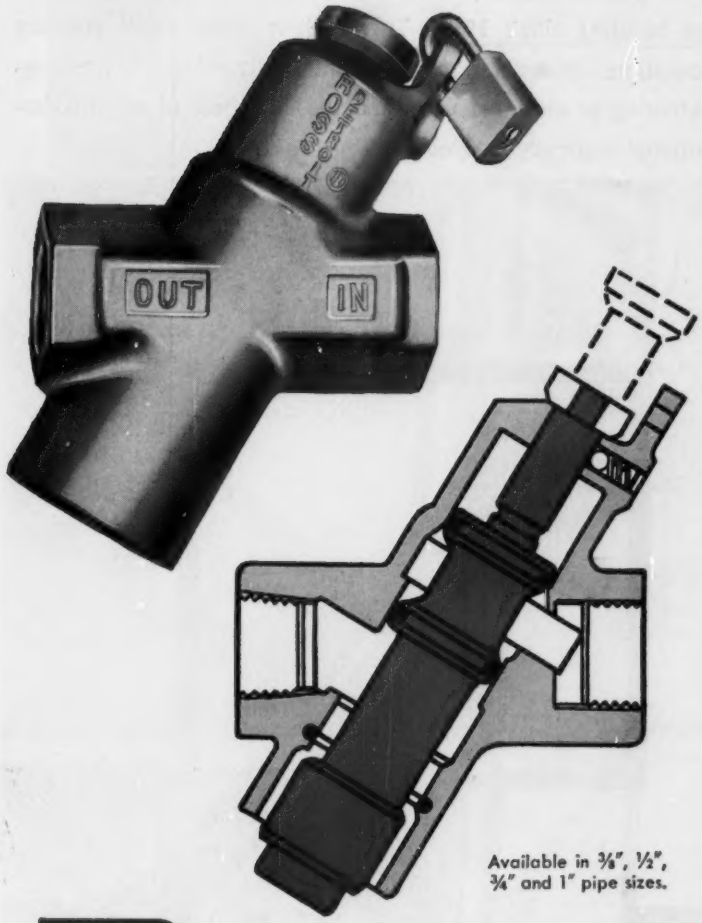
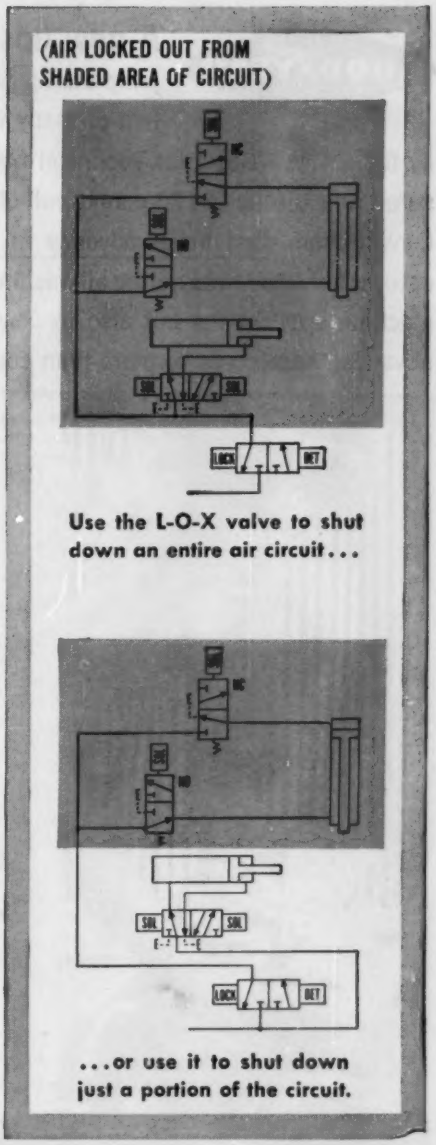
BOUND BROOK

Bound Brook Oil-less Bearing Co., Bound Brook, N. J.
Pioneer in Powder Metallurgy Bearings and Parts.
Plants at Bound Brook, N.J. and Sturgis, Mich.

Lock out air for machine repair



Available in ⅜", ½", ¾" and 1" pipe sizes.


(AIR LOCKED OUT FROM SHADED AREA OF CIRCUIT)
Use the L-O-X valve to shut down an entire air circuit...
...or use it to shut down just a portion of the circuit.

Ross L-O-X VALVE

(Lock—Out—eXhaust)

Now you can actually lock out air that operates a machine, as a safeguard when making machine repairs. The Ross L-O-X Valve installs in the supply line leading to the machine, upstream of any operating valve. It is so designed that when closed, supply-air to the machine is shut off and air downstream is exhausted. The valve can be *padlocked* in this position.

More L-O-X valves can be incorporated in the circuit to shut off and exhaust various segments of the circuit. Thus portions of the circuit can be available for maintenance service without shutting down the entire circuit. Detented in the open position, designed for very low pressure drop. Lightweight aluminum construction. Call your Ross representative or write for literature.

Ross OPERATING VALVE COMPANY

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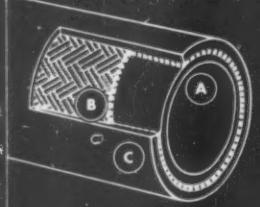
GOODYEAR

A new hose that won't pull itself out of couplings — won't jump during pressure changes — remains "relaxed" — answers a long-time problem of many washing-machine manufacturers. Called Acala, it was designed by the G.T.M. — Goodyear Technical Man — and his colleagues to minimize hose shrinkage under pressure — and the up-to-170-pound pull-off force that shrinkage produces. The secret: a unique Goodyear construction — first major advance in hose building since 1904. This built-in dimensional stability assures a relaxed hose during all washing operations—brings new reliability and safety not only to washing-machine applications but also to power steering or air-brake units and the like. Best of all, this far-advanced hose costs no more than conventional vertically braided types.

GOODYEAR INDUSTRIAL PRODUCTS

GTM-Specified

Acala Hose that won't shrink under internal pressure



A Nonporous, non-clogging, heat-resisting rubber tube

B Special optimum-angle-braided construction minimizes shrinkage under internal pressure

C Non-marking, heat-resistant cover

The G.T.M. — and the tremendous Goodyear research facilities — are always at work on real advances in industrial rubber like this.

That's why they've made so many important contributions to every rubber-using industry. It's the big reason, too, why you can always count on Goodyear for problem-solvers like the new Acala Hose. For full details, write Goodyear, Industrial Products Division, Akron 16, Ohio.

Lots of good things come from

GOODYEAR

Acala—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

THE GREATEST NAME IN RUBBER

Front Cover: Oscillating motion is studied by artist George Farnsworth as he takes a close look at the special bearings designed for such service. Design details of these high-performance bearings are covered by C. M. Daniels on Page 136.

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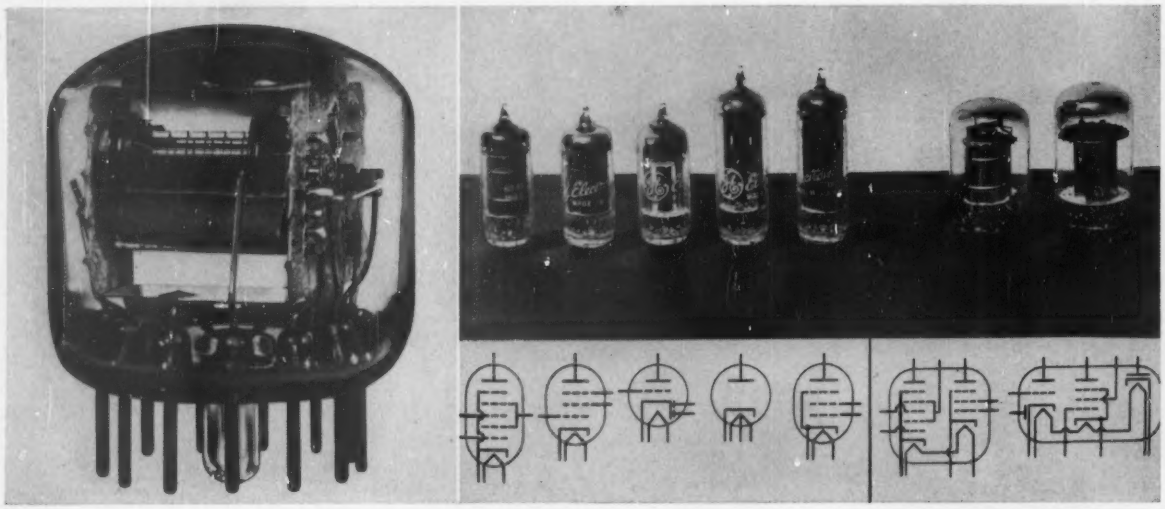
ENGINEERING NEWS

Compactron: Three-in-One Vacuum Tube



Horizontal mounting of the internal structures (left) accounts for the exceptionally low seated height and permits multifunction operation by a small vacuum tube. Tube shown is a combined frequency converter and intermediate-frequency amplifier, but other combinations are also possible.

The two compactrons (right) replace the five miniature tubes (12BE6, 12BA6, 12AV6, 35W4, and 50C5) in an experimental radio receiving set, and other tubes are still being developed. Compactrons, developed for radio, TV, and hi-fi, will soon find other applications, GE spokesmen predict.

SCHENECTADY, N. Y.—Radios, hi-fi sets, and TV receivers will soon perform better, take up less space, and cost less, thanks to a new family of small multifunction vacuum tubes called compactrons. Developed by General Electric Co., compactrons outperform standard tubes and transistors and cut down both the number of components needed and the complexity of circuits. Price estimates show that production models will cost about 20 per cent less per function performed than conventional tubes.

According to GE the compactrons handle combinations of electronic functions that normally require up to three separate devices (tubes or transistors). A two-compactron radio has already been demonstrated. A TV set using ten of the devices (instead of 15 tubes and 3 diodes, or 24 transistors and 11 diodes) and hi-fi equipment using four (instead of 6 tubes or 11 transistors) are also possible.

Compactrons had to await new metallurgical developments that led to improved thermal efficiencies for tube materials. One of the most important of these developments was a new material that reduces heat required by the anode 40 per cent; another was a clad material that improves both the hot strength and thermal efficiency of cathode elements, GE engineers report. One result of the metallurgical developments is the use of an integral heater which heats three separate cathodes. Integral heaters aren't new of course, but "this is the first large-scale application where elements with three-heater functions have been combined in one continuous unit," says C. D. McCool, manager of product design at GE's electronic components plant, Owensboro, Ky.

To date, three different types of multifunction compactrons have been developed:

- A combination oscillator, converter, and intermediate-frequency amplifier (designed to displace the 12BA6 and 12BE6).
- A second detector, audio amplifier, audio power output amplifier, and rectifier (to do the job of a 35W4, 50C5, and 12AV6).
- A horizontal oscillator and automatic-frequency control (to replace a 6CG7 and 6AL5).

In addition, three other models have been developed to replace single tubes. These single-function compactrons are significantly smaller than conventional tubes and are designed to take over jobs where power requirements are close to maximum limits for one unit, or where operating voltages are relatively high.

Plans for broadening the compactron line include addition of nine new types within the next year. Long-range plans indicate the line will eventually include 75 to 100 types. Present applications are all in the home-entertainment field, but GE spokesmen say the devices also have potential in industrial control and instrumentation fields and in two-way communication equipment. In these areas, the advantages of smaller size and multifunction capability would be equally strong.

Fluid Power NEWS

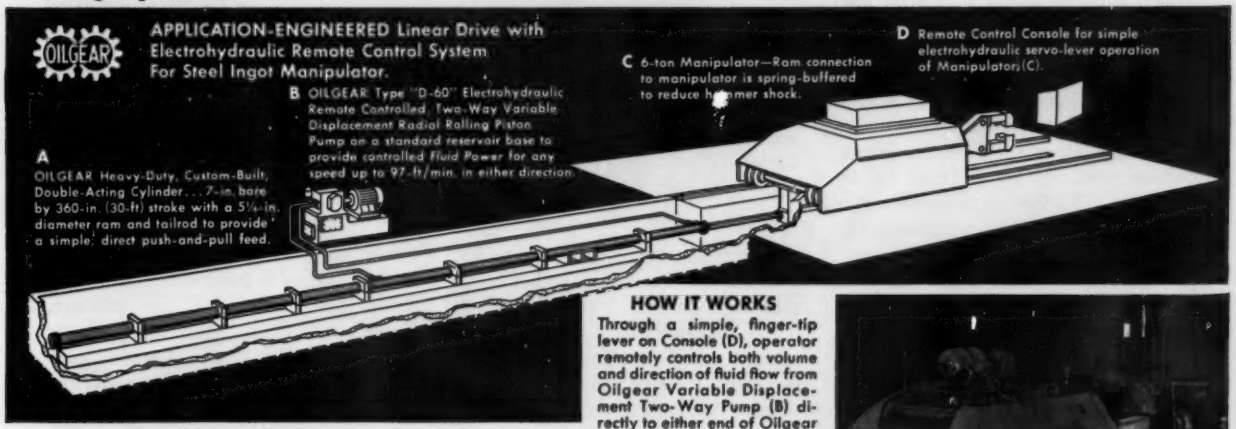
REPORT NO. 11,801 REMOTE CONTROLLED INGOT MANIPULATOR

From Oilgear *Application-Engineering* Files

HOW OILGEAR DRIVE SYSTEM ON INGOT MANIPULATOR IMPROVES CONTROL—CUTS DOWNTIME

DATA: Replace an electric variable speed drive on a 6-ton ingot manipulator because of excessive maintenance downtime, high rebuilding and replacement costs. Initial replacement plans called for a hydraulic variable speed drive directly to manipulator wheels, retaining customary practice of operators riding on manipulator. A job study revealed that while feeding an ingot under the open frame steam hammer, forward motion is momentarily stopped by each hammer impact—frequently bouncing manipulator wheels in the air, causing traction, speed control, shock, and operator fatigue problems.

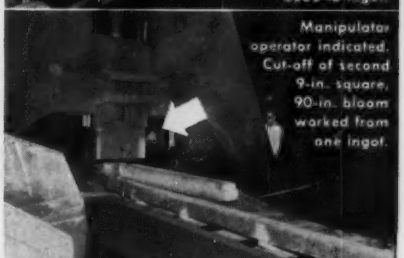
Basic Manipulator Drive Requirements were re-evaluated as follows: 1. Remove drive from manipulator to reduce shock-provoked maintenance downtime. **2.** Drive to be independent of wheel traction to improve feed and control. **3.** Provide stepless, remote speed control from zero to maximum in both directions. **4.** Withstand severe shock, vibration, heat, and dust on a continuous 16-hour day basis. **5.** Reduce operating, maintenance, and installation costs. **6.** Provide for future incorporation of hammer control with remote manipulator console.


APPLICATION-ENGINEERED Linear Drive with Electrohydraulic Remote Control System For Steel Ingot Manipulator.
A OILGEAR Heavy-Duty, Custom-Built, Double-Acting Cylinder . . . 7-in. bore by 360-in. (30-ft) stroke with a 5¼-in. diameter ram and tailrod to provide a simple, direct push-and-pull feed.
B OILGEAR Type "D-60" Electrohydraulic Remote Controlled, Two-Way Variable Displacement Radial Rolling Piston Pump on a standard reservoir base to provide controlled Fluid Power for any speed up to 97-ft/min. in either direction.
C 6-ton Manipulator—Ram connection to manipulator is spring-buffered to reduce hammer shock.
D Remote Control Console for simple electrohydraulic servo-lever operation of Manipulator (C).

HOW IT WORKS

Through a simple, finger-tip lever on Console (D), operator remotely controls both volume and direction of fluid flow from Oilgear Variable Displacement Two-Way Pump (B) directly to either end of Oilgear Custom Cylinder (A). Only two pipe lines are required. Power input is used only in proportion to work performed, as no pump output power is wasted in direction control valves, external relief valves, flow control valves, auxiliary components, or excessive piping. Stepless, infinitely variable, smooth, steady manipulator speeds are instantly available in either direction. Fluid flow and pressure decelerate to zero as flow direction is changed—flow and pressure then accelerate to any selected amount in the new direction . . . reversal is smooth-cushioned — shock is eliminated. Controlled acceleration and deceleration; hydrodynamic braking; automatic pressure and flood lubrication; continuous filtration of power fluid . . . all are inherent features of Oilgear "Any-Speed" Drive Systems.

Hammer operator indicated Oilgear-powered Manipulator with 5300-lb ingot.


Manipulator operator indicated. Cut-off of second 9-in. square, 90-in. bloom worked from one ingot.

SOLUTION: An Oilgear Linear Drive and Electrohydraulic Control System as shown above schematically. This departure from customary manipulator drives has proved—*in over two years of operation*—to have the following advantages: **1.** Lower operating costs . . . previous manipulator averaged 12% to 15% downtime every 16-hour day for repair and adjustment of drive and control components. **2.** Direct push and pull linear drive is a more positive, smoother, shockless feed—NOT affected by variations in wheel traction. **3.** Remote console with simple electrohydraulic servo control eliminates operator discomfort and fatigue. **4.** Cylinder is protected below floor—"Power-Pak" is mounted away from heat and dust of work area. **5.** Constant, automatic overload protection insures longer life, prevents damage.

System was selected due to Oilgear's reputation for trouble-free reliability, long life, simplicity, and on-the-job-proved performance of the following *Oilgear-Powered* equipment in this user's plants . . . 300-ton ingot strippers . . . large forming presses . . . tube pointing presses . . . hydrostatic testers . . . stripping presses . . . pipe benders . . . seamless steel tube piercers . . . planers . . . cut-off machines . . . tube threaders—operating efficiently—in constant, daily use—some have been in service for more than 20 years.

User Reports—" . . . well pleased with the steady feed rate at both low and high speeds . . . we'll go to this type of drive when we rebuild or require another Manipulator."

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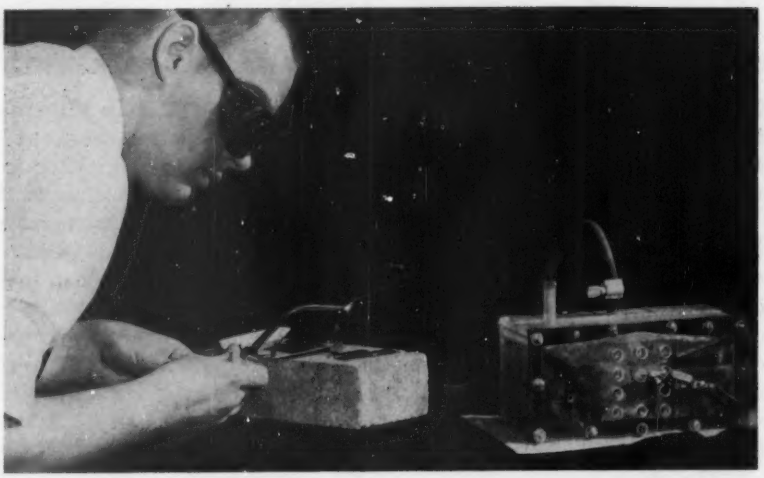
Experimental Gas Cell Powers Metal-Forming Explosions

COLUMBUS, OHIO—Best fuel source yet conceived for explosive-forming operations may prove to be an electrolytic gas cell now under development. An experimental cell built at Battelle Memorial Institute produces varied oxygen-hydrogen mixtures to control ignition temperature, detonation rate, and pressure. With it, forces of as high as 15,000 tons can be directed against a 2000-sq in. surface.

Gas fuel for explosive forming operations has several potential advantages over conventional fuels, says Battelle's Dr. John McCallum. When solid or liquid explosives are used, millions of psi pressure form the metal within a few microseconds. But shock waves often reflect back to reinforce the next wave and sometimes crack the workpiece.

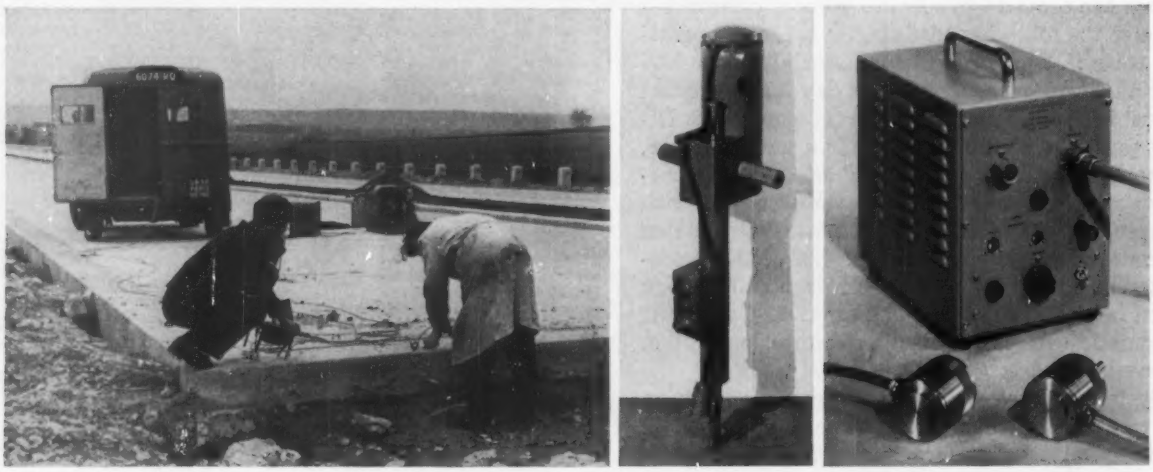
Gas explosions, on the other hand, reduce pressures by a factor of at least ten. Rather than reaching a high level almost instantaneously and then dropping abruptly, gas-explosion shock waves build up and taper off slowly (within several milliseconds). The over-all effect is that a lesser force is applied for a longer time—and this may prove easier to control.



Other applications for Battelle's gas cell are also under study. As a fuel source for high-temperature welding and cutting torches, the device generates a mixture able to produce flame temperatures above 2000 C—hot enough to cut and weld steels, aluminum, and nickel. By varying the moisture in the gases (to control flame temperature) and adding trace amounts of caustic (to form a yellow, easily adjustable flame), researchers have a highly versatile torch.

The generator, continues Dr. McCallum, consists of a number of flat nickel-plated steel electrodes placed 0.060 in. apart in a plastic or insulated-metal container. Electrolyte is a weak caustic solution. Volume of gas generated depends on the number of electrodes and input current. Safety is inherent: Auto-ignition temperature of the mixture, about 600 C, is much too high for accidental ignition, and gas is generated only as needed—eliminating shipping and storage problems.

Synthetic Seismology Determines Concrete Characteristics



Nondestructive "sounding" is a new technique now available for determining dynamic-elasticity modulus and Poisson's ratio in concrete structures. Equipment, designed by Laboratoire Electro-Acoustique, Ruel-Seine-et-Oise, France, is adaptable to structures ranging from 2 in. to 330 ft thick. A selection of electromechanical hammers (small, medium, or large, depending on cement thickness) serves as transmitters (center); a magnetorestrictive detector (right) picks up sound waves at a predetermined distance from the hammers. Time of sound-wave travel through the concrete is read on the screen of a cathode ray tube. The equipment measures longitudinal waves, transverse and Rayleigh waves.

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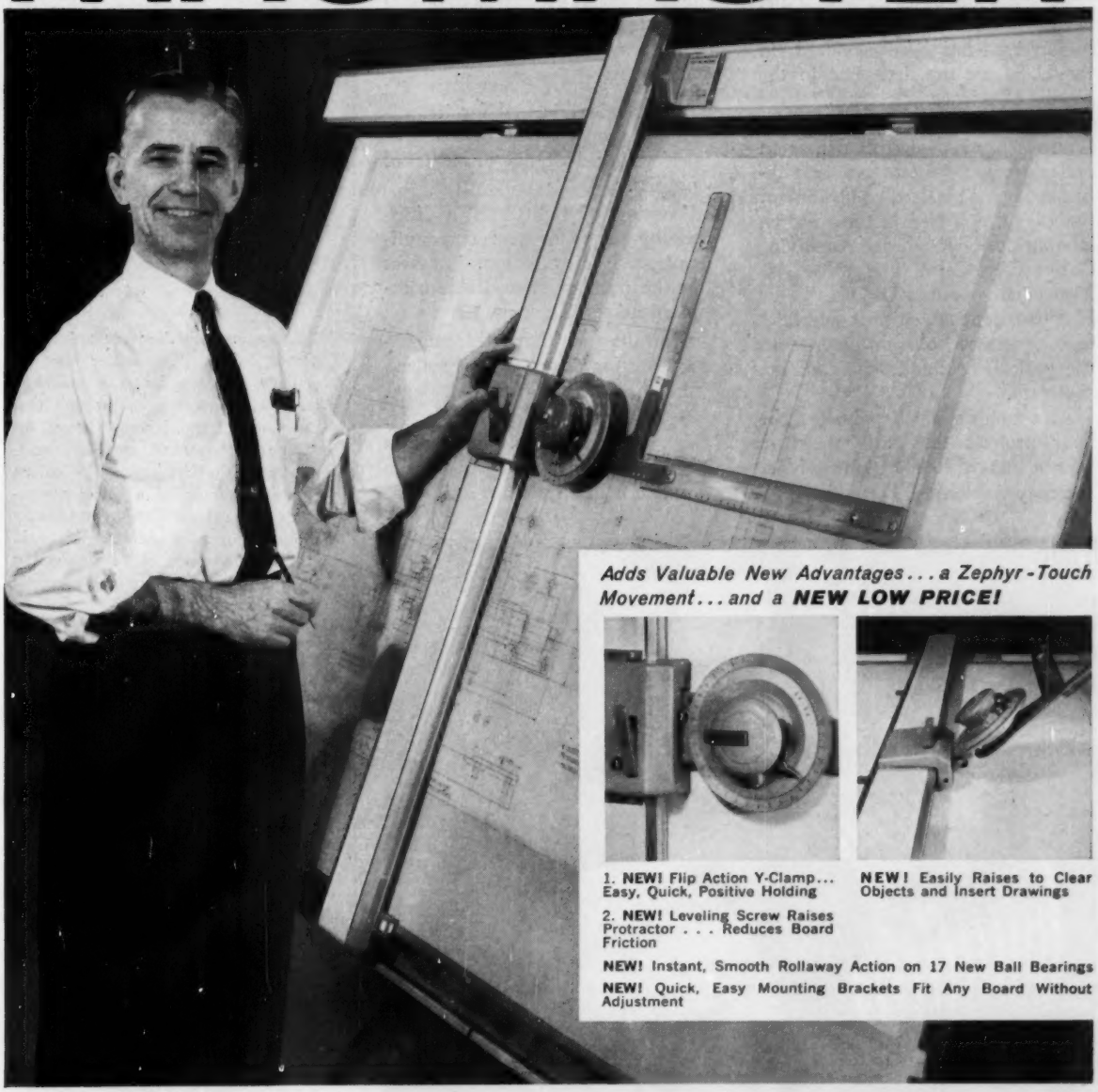

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Circle 408 on Page 19

"Laser" Cracks the Microwave Barrier

First Source of Coherent Light Created by Hughes Researchers

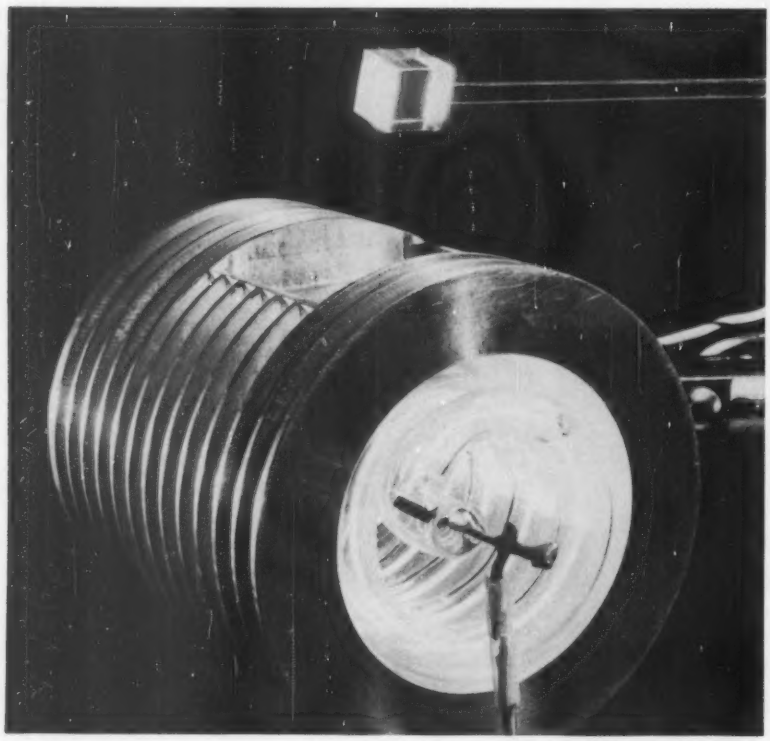
NEW YORK — True amplification of light—extending the electromagnetic spectrum downward into the visible frequency range of 500,000 billion cps—has been achieved, in the U. S., for the first time in the history of science.

Key to the startling development is an electronic device, known as an optical maser (microwave amplification by simulated emission of radiation), designed in the research laboratories of Hughes Aircraft Co., Culver City, Calif. The device was immediately dubbed "laser" by Hughes scientists, since it amplifies and generates coherent energy in the optical, or light, region of the spectrum.

As a major scientific advance, the laser projects the radio spectrum into a range 10,000 times higher then present limits. The radio spectrum is the range of electromagnetic frequencies starting with commercial radio at one million cps and extending into the upper microwave region of 50,000 million cps. The laser jumps the gap from 50,000 million to 500,000 billion cps, opening the way for a host of important applications:

- A new scientific tool for investigating properties of matter and performing basic experiments of physics.
- Focusing of light into high-intensity beams for space communications, leading to vast increases in the number of available communications channels.
- Utilization of high light concentration for industrial, chemical, and medical purposes.

According to Dr. Theodore H. Maiman, who headed the Hughes research team, essential steps in the operation of the laser are simple, at



Synthetic ruby and random light source are basic components of the laser. Chromium ions in the ruby are excited by energy from the powerful, pulsing flash tube lamp. Net effect is stimulated emission instead of absorption . . . the excited atoms are coupled to an optical resonator and stimulated to emit radiation together (i.e., coherently). The present laser, rated at 10 kw, is about 1 per cent efficient. Efficiency of 10 per cent is expected in the near future.

Topics

Forgers are foiled by the Autho-Visor signature system, which puts optically scrambled signatures on identification cards, then decodes them in a special reading device. The signature can't be copied, but a bank teller using a decoder can compare it with the customer's signature on a withdrawal slip. Elimination of the need for checking signatures with a central card file saves time and also permits a customer to make withdrawals at any branch of a bank using the system. Besides banks, other users of Autho-Visor may be credit-card and charge-account businesses and Defense Dept. security officers. The system was developed by LeFebure Corp., a subsidiary of Craig Systems Inc., Lawrence, Mass.

• • •

Computers have limitations, just like human brains. "No matter how big or how fast you design a computer, there will always be a problem that can stop it," says Harvey Garner, associate professor of electrical engineering at the University of Michigan and co-chairman of a summer computer course there. The largest-capacity computers now in use store 12 to 15 million units, each of which requires a vacuum tube or a spot on a magnetic tape or drum.

• • •

Doing something about the weather, National Appliance Co. builds growth chambers which plant and forestry biologists consider the "greatest weapon since fertilizer." Climate is controlled completely in the chamber, permitting researchers to speed up or slow down the development of crops which they are studying.

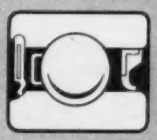
• • •

Box lunch in the clouds comes from a 600-lb, plastic and metal buffet which measures slightly under 3 by 4 by 5 ft. Such a unit was recently designed by United Airlines engineers for their new jets "to permit stewardesses to serve everything ranging from a cup of coffee to a full-course dinner." The buffet rolls through washing and packing areas and onto the plane, where it serves as storage space, setup counter, table, coffee maker, water cooler, oven, roll warmer, waste disposal, and milk and stronger drink service. It stores dishes and ice cubes. During development, crews tested designs by cooking meals, loading the units on planes, and serving meals while methods engineers timed operations with stop watches.

PRODUCT INFORMATION

NEW LAND-RIDING SEAL (Crimped)

N/D's newest seal design. Efficient single lip, low-torque seal protects against moist or dry contaminants. Retains bearing lubricant-for-life. Recommended for farm implement discs, idler pulleys, wheels and similar applications. Available also with metal trash guards to protect seal against mechanical damage from trash windings.



NEW LAND-RIDING SEAL (Pressed) and SENTRI-SEAL

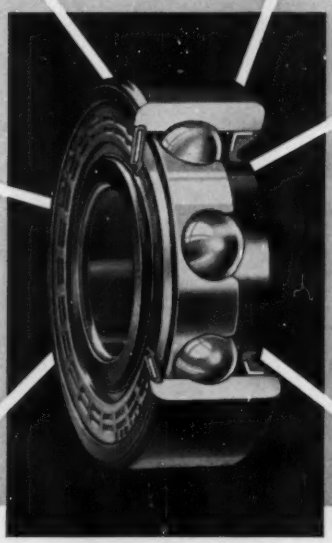
This exclusive seal combination is available in N/D's new heavy-duty conveyor ball bearings. Land-Riding seals, especially resistant to moist contaminant penetration, are available separately in N/D's bearings for hay rake tine bar, plow, hiller and coulter applications. Tandem seal arrangements are also available.

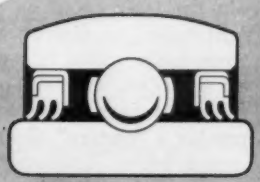
NEW SENTRI-SEAL

N/D's most versatile seal . . . available in most single row, non-loading groove and small double row N/D ball bearings. N/D Sentri-Seals are recommended for applications with moderate to severe contaminant conditions as found in light duty discs, idler pulleys, cam followers, implement wheels, adapter bearings and similar applications.

NEW DOUBLE "O" SEAL

N/D's most original seal design, used in fan and water pump bearings where water seepage is prime source of bearing contamination. Synthetic rubber seal rides smooth shaft O.D., offers reliable low-torque sealing and eliminates relubrication.





NEW TRIPLE LIP SEAL

N/D's most rugged seal . . . used where moist and dry contaminant conditions are most severe. Seal eliminates relubrication maintenance. It's available in N/D square and round bore ball bearings with either spherical or cylindrical O.D.'s.

Introduces 5 New Integral Ball Bearing Seals!

Now, New Departure offers a versatile line of new integral seals for N/D precision ball bearings. Each N/D seal is engineered to retain bearing lubricant for life . . . and offer maintenance-free service. These seals are designed to give manufacturers a broad selection to choose from for a specific application.

Modern design N/D seals are made of synthetic rubber with supporting steel components for precise control of sealing lip flexibility and torque. Whatever the application, you'll find an N/D integral seal and ball bearing to fit it. All seals are available in popular sizes of New Departure ball bearings.

Write today for N/D's Integral Seal Bulletin. For detailed information, contact the N/D Sales Engineer in your area. New Departure Division, General Motors Corporation, Bristol, Connecticut.

NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around

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least from the scientist's point of view. In sequence:

- A light source, such as powerful flash tube lamp, irradiates a synthetic ruby crystal.
- The optical energy excites the atoms to a higher energy state from which energy is reradiated in a narrow band of frequencies.
- The excited atoms are coupled to an atomic resonator and stimulated to emit the radiation together; hence the acronym laser. This is in contrast to ordinary light sources where atoms radiate individually (at random), producing incoherent light.

Dr. Maiman said that the laser could be described as an "atomic radio-light" because its coherent properties are similar to radio waves and it uses atomic methods to generate light beams "brighter than those of the sun or stars, even at their hottest centers."

He said the laser could be used as a "light radar" to direct waves, rather than radio waves or microwaves, to a target, even in outer space. Reflected back, these waves would provide a "picture" of superclarity never before attainable."

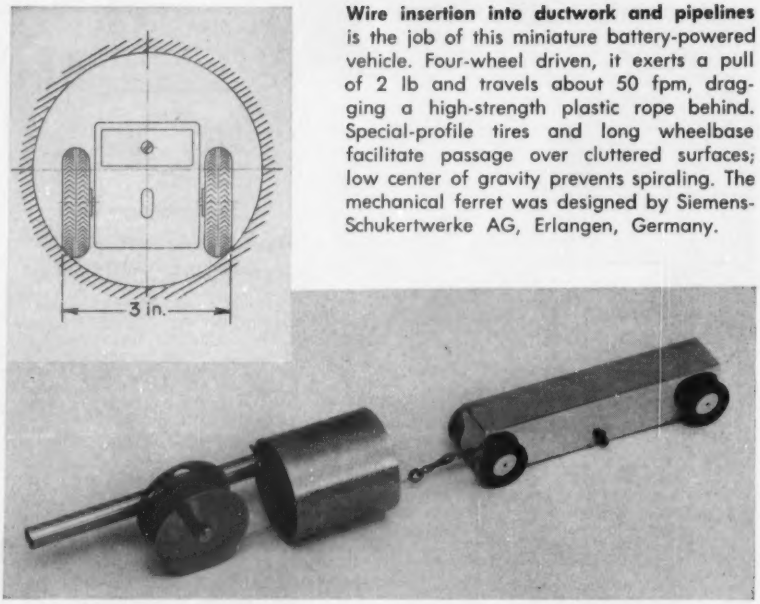
For use in TV and voice communications, the needle-sharp light beam provides a secure "private line" free from static, and resists deliberate jamming.

The laser's use in radar and communications for space work is obvious since there is no atmosphere in space to absorb or scatter the beams. The high resolution resulting from its sharp beams would enable man to take detailed pictures of any area. For example, a beam directed at the earth from a satellite 1000 miles up could be concentrated in an area about 200 feet wide.

Declaring that lasers could generate "the purest colors known," Dr. Maiman explained that in principle, light waves could be produced more than a million times as monochromatic as those from a mercury or neon lamp.

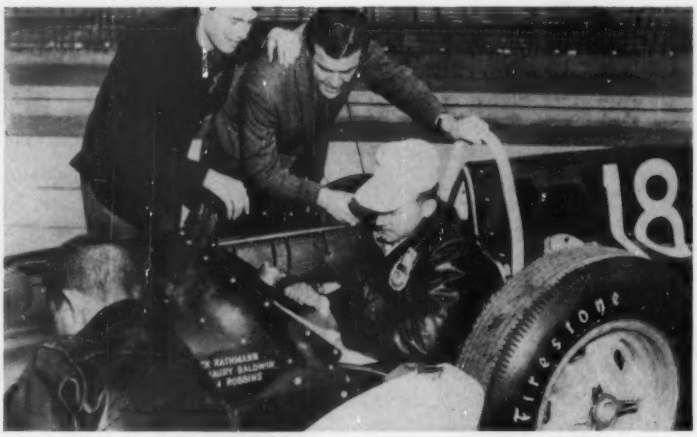
To generate a light wave as intense as that produced by a laser, a carbon-arc Hollywood klieg light theoretically would have to reach a temperature of several billions of degrees (the surface of the sun is 6000 C).

Duct Truck

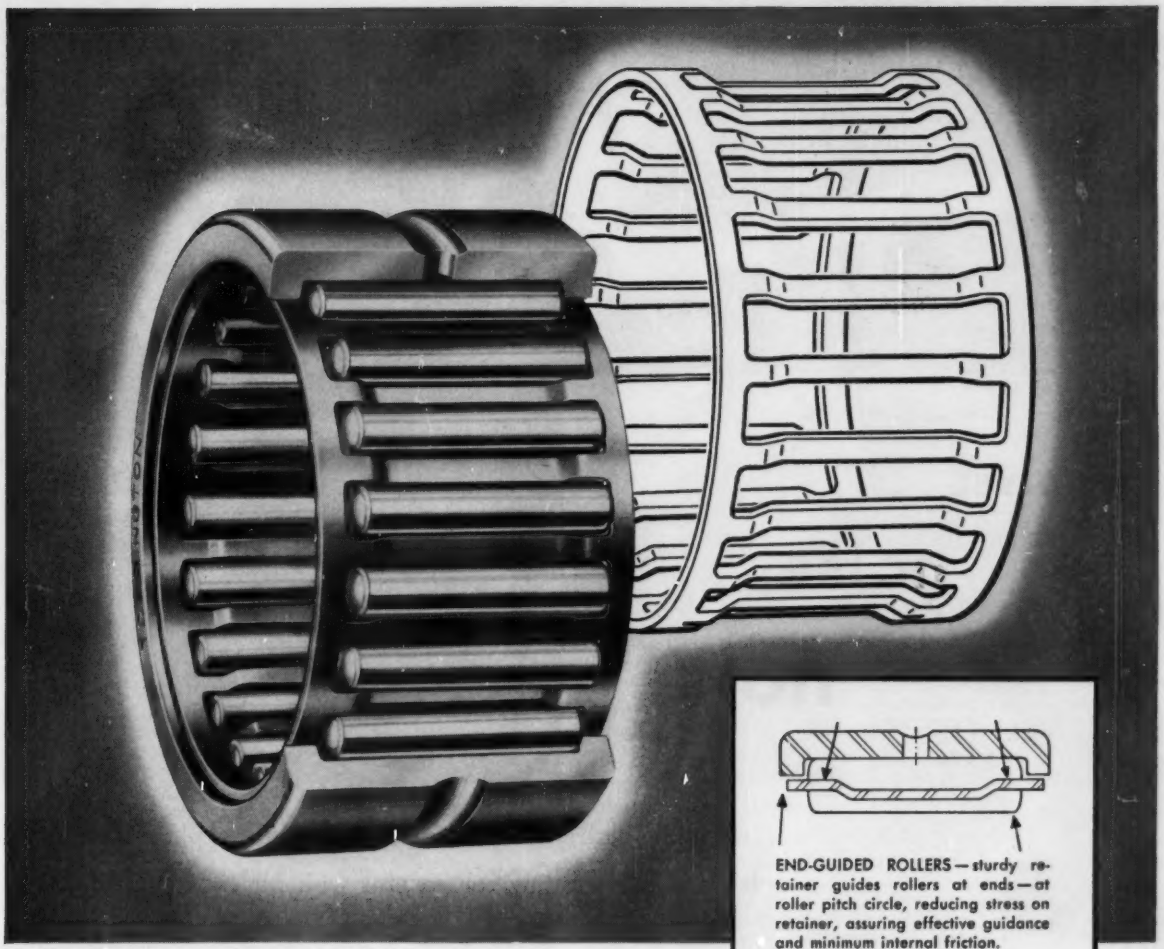


Wire insertion into ductwork and pipelines is the job of this miniature battery-powered vehicle. Four-wheel driven, it exerts a pull of 2 lb and travels about 50 fpm, dragging a high-strength plastic rope behind. Special-profile tires and long wheelbase facilitate passage over cluttered surfaces; low center of gravity prevents spiraling. The mechanical ferret was designed by Siemens-Schukertwerke AG, Erlangen, Germany.

Exhaust Gases Boost Racer Thrust



Roaring through the cockpit only inches from the driver, 1500-F exhaust gases, jetted through a tailpipe, helped to power two Jim Robbins' racing cars to sixth and ninth places in the Indianapolis 500-mile Memorial Day classic. Robbins, the only owner to have two cars finish in the money, credits his exhaust system for the excellent showing. On each car, engine exhaust, fed into a jet tube that ran completely through the right side, blasted out the rear to provide extra thrust and lessen centrifugal force (by lessening the weight on the right side). Drivers of the two cars claim an added advantage for the jet: It kept trailing cars off their tails by "blowing them back." The drivers also agreed on another point: They were not uncomfortable because of the searing exhaust heat. Jet tubes were covered with Cerafelt liners (a Johns-Manville insulation that's more at home on jet-airplane exhaust cones and tail pipes). The insulation, in turn, was covered by stainless-steel outer walls. Drivers remained cool—even though their right elbows sometimes rubbed against the exhaust tubing.



The New *Torrington Heavy Duty Roller Bearing*

Key to Long Life... Roller Guidance Where It Counts!

This sturdy flange-riding retainer in Torrington Heavy Duty Roller Bearings insures the highest degree of roller guidance where it's most effective... at the roller ends along the pitch circle. You get outstanding service life through minimum internal friction, high roller stability and efficient lubrication.

Controlled contour rollers prevent high end-stress concentrations. Careful heat treatment of the channel-shaped outer race insures high shock resistance. The Heavy Duty Roller Bearing has proved successful under unusual conditions of deflection or misalignment. Torrington Heavy Duty Roller Bearings are giving longer life in such difficult applications as two-cycle engines, hydraulic pumps, oil-field equipment, sheaves and transmissions. For design and application assistance on the Heavy Duty Roller Bearing—and every basic type of anti-friction bearing—call your Torrington District Engineer.

END-GUIDED ROLLERS—sturdy retainer guides rollers at ends—at roller pitch circle, reducing stress on retainer, assuring effective guidance and minimum internal friction.

UNIFORM LOADING—Torrington controlled contour rollers eliminate stress concentration at roller ends. End-stress pattern of unrelieved cylindrical rollers is shown in black outline. Area in gray shows uniform loading over entire contact length of Torrington rollers.

AMPLE LUBRICANT STORAGE AREA is provided by the retainer design, which also allows unrestricted flow of lubricant within the bearing.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

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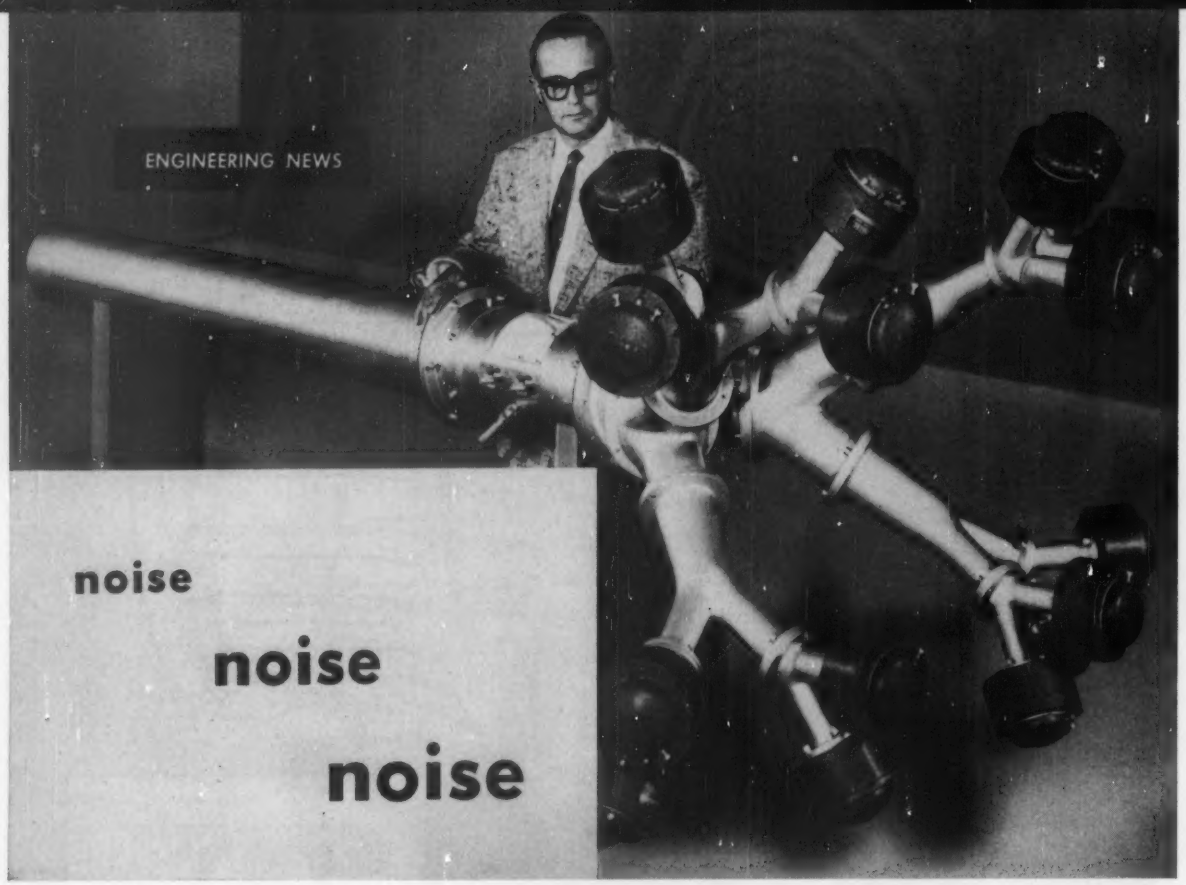


noise noise noise

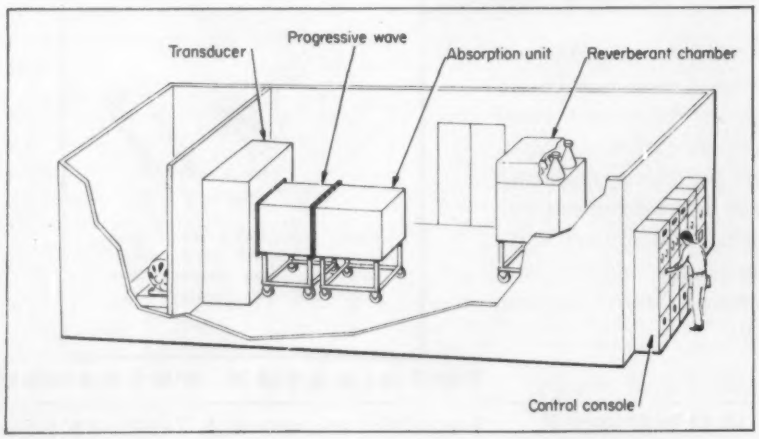
. . . is the destructive product of this 16-driver plane-wave tube. It's a tool for testing components with high-energy sound.

ANAHEIM, CALIF. — Although noise is always a nuisance, many engineers are coming to regard it as a deadly menace. Sonic vibrations in a missile are known to impose "ghost" instructions on its flight path. High-intensity sound in aircraft has frequently caused structural failure, or malfunction of delicate pneumatic and hydraulic systems within the vehicle.

Because the complexities of noise generation defy analysis, designers are forced to resort to component testing. Latest entrant in the field is Ling Altec Electronics, Ling Electronics Div., which operates a modern test laboratory incorporating many of its own sound-generator designs.

Typical of the "big-noise" generators is an air-modulated loudspeaker capable of producing 10 to 15 db more acoustic power than conventional dynamic speakers. Ling will use the new speaker in reverberant boxes which can accommodate large pieces of equipment.

Acoustics experts have found that simply increasing the number of speakers in a reverberant box increases the peak power only to a point. When more than one-quar-



Acoustic test facility simulates free-field conditions. Until analysis improves considerably, the facility is one of the only practical means of designing noise-proof components.

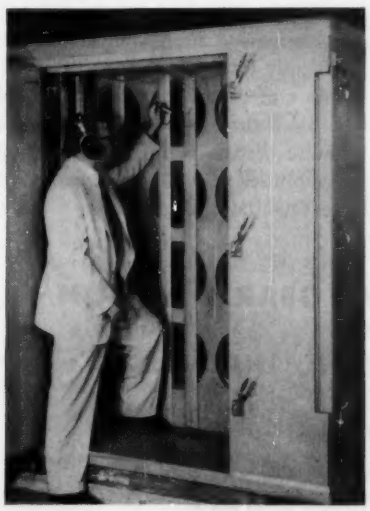
Reverberant chamber contains 32 low and high-frequency speakers. Sound pressure level in this box exceeds 140 db; outside, it's damped to a quieter 110 db.

ter of the available wall space is filled, the speakers begin absorbing more noise than they generate. However, with more powerful speakers, Ling engineers are able to maintain noise levels of 150 db for extended periods. Usually, reverberant boxes are built in an irregular shape to produce a dense spectrum of frequencies, independent of the character of the speakers used.

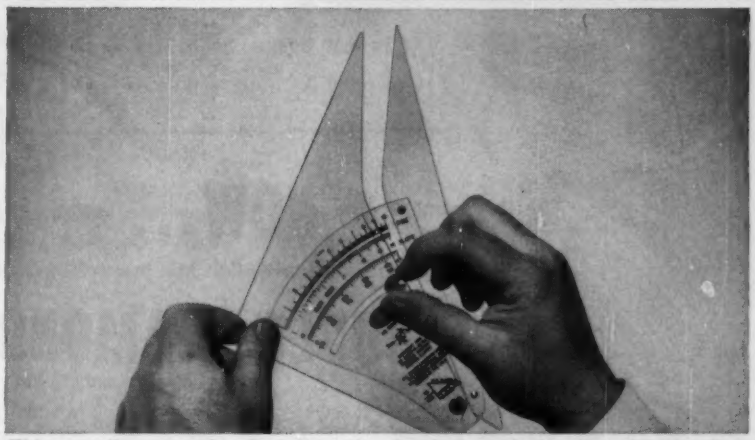
But the reverberant box does not create as much noise as another type of sonic chamber—the plane wave tube. Ling's 8-in. tube (shown on opposite page) can produce levels up to 160 db with far better accuracy than the reverberation chamber. Principally used to test small pieces of equipment, the plane wave tube creates a free field without cross-modes.

The unidirectional nature of the field allows equipment to be tested for acoustic sensitivity in a specified direction. This, in turn, can dictate mount positions or give a clue to best orientation of delicate instruments.

Ling's acoustic engineers are quick to point out that, in today's high-speed missiles and aircraft, the dominant source of high-intensity noise is not the propulsion units. It is the aerodynamic turbulence generated by the vehicle. This turbulence—pressure fluctuations in the boundary layer—is not itself an acoustic source. However, the skin of the vehicle transduces the pressure fluctuations to sound—and this sound is emitted. Its energy causes structural damage, not only to the skin, but to delicate instruments and machinery.



DRAFTING TRENDS



This versatile, easy-to-handle, adjustable triangle is made of yellow-tinted optical-grade acrylic plastic. A clean-cut oval track fitted with metal knurled knob assures ease of operation and lasting tight fit.

New combination protractor-triangle speeds up drafting

Architects, Engineers, Builders, Field Surveyors, Mathematicians—anyone who develops solutions to measurement problems indirectly to determine a wanted measurement graphically or mathematically—will find the Trig-Matk Adjustable Triangle a handy tool. It eliminates much of the graphic work necessary in estimating results or in checking for correct answers.

Versatility with accuracy

Basically, the new POST Trig-Matk Adjustable Triangle is a mathematician's tool—accurate to two decimal places.

It combines the functions of a protractor and a triangle into a simple unit, with two fundamental trigonometric relationships of a right triangle. The Trig-Matk provides accuracy within 1% in problems dealing with any of the six trigonometric ratios of the sides of a right triangle.

The adjustable protractor has three sets of graduations. One set is graduated in half degrees, labeled *Degrees*, and permits the use of the Trig-Matk as a protractor setting for determining any angle from 0 to 90 degrees.

The second set of graduations, labeled *Slope*, shows directly the *Secant* trigonometric ratio of the angle indicated on the degree scale. The third scale, labeled *Rise*, indicates directly the *Tangent* trigonometric ratio shown on the degree scale.

Examples

This new tool has a host of drafting and engineering applications. Highway designers find the Trig-Matk very useful when making cross sections of roadways at ground level or below. By setting the *Slope* scale to the degree desired, road-curve grades are automatically determined. The protractor can be used to determine the angle of highway ingress and egress lanes.

An indicated angle of 40 degrees on the Trig-Matk (1589) shows directly that the Rise is 8.4 to the base of 10.

Structural Engineers will find the Trig-Matk Adjustable Triangle a simple tool, eliminating the use of both a scale and individual triangles. In addition to the time saved, many of the errors usually associated with the older method are avoided. The Trig-Matk design eliminates the need of frequent reference to handbooks for information on various bevels.

Two Bases

The Trig-Matk No. 1589-12 has a 12" base for handy calculations in feet and inches. Number 1589-10 has a base of 10 for decimal calculations.

Keep posted on all the latest trends in drafting. Consult your local POST dealer, or write to Frederick Post Co., 3652 North Avondale Ave., Chicago 18, Ill.

POST

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ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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HIGH-REDUCTION BEVEL GEARS

To the nine gear types* already made by us for a long list of leading manufacturers, we now add High-Reduction Bevel Gears to meet a growing demand for the economy and speed reduction accomplished by this type of power transmission.

These DOUBLE DIAMOND High-Reduction Bevel Gears will supply speed reduction normally considered impractical in a single gear set of this type. In many cases they will replace more complex and more costly gear systems, thus improving design and achieving simplicity, while considerably lowering costs.

One of our gear engineers would be more than pleased to meet with you to discuss fully the interesting possibilities of this new member of the DOUBLE DIAMOND family.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

* Angular bevel gears, Helical gears, Spur gears, Flywheel ring gears, Hypoid bevel gears, Straight bevel gears, Spline shafts, Zerol† bevel gears, Spiral bevel gears. Also gear assemblies.

†REG. U. S. PAT. OFF.

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for More Information . . .

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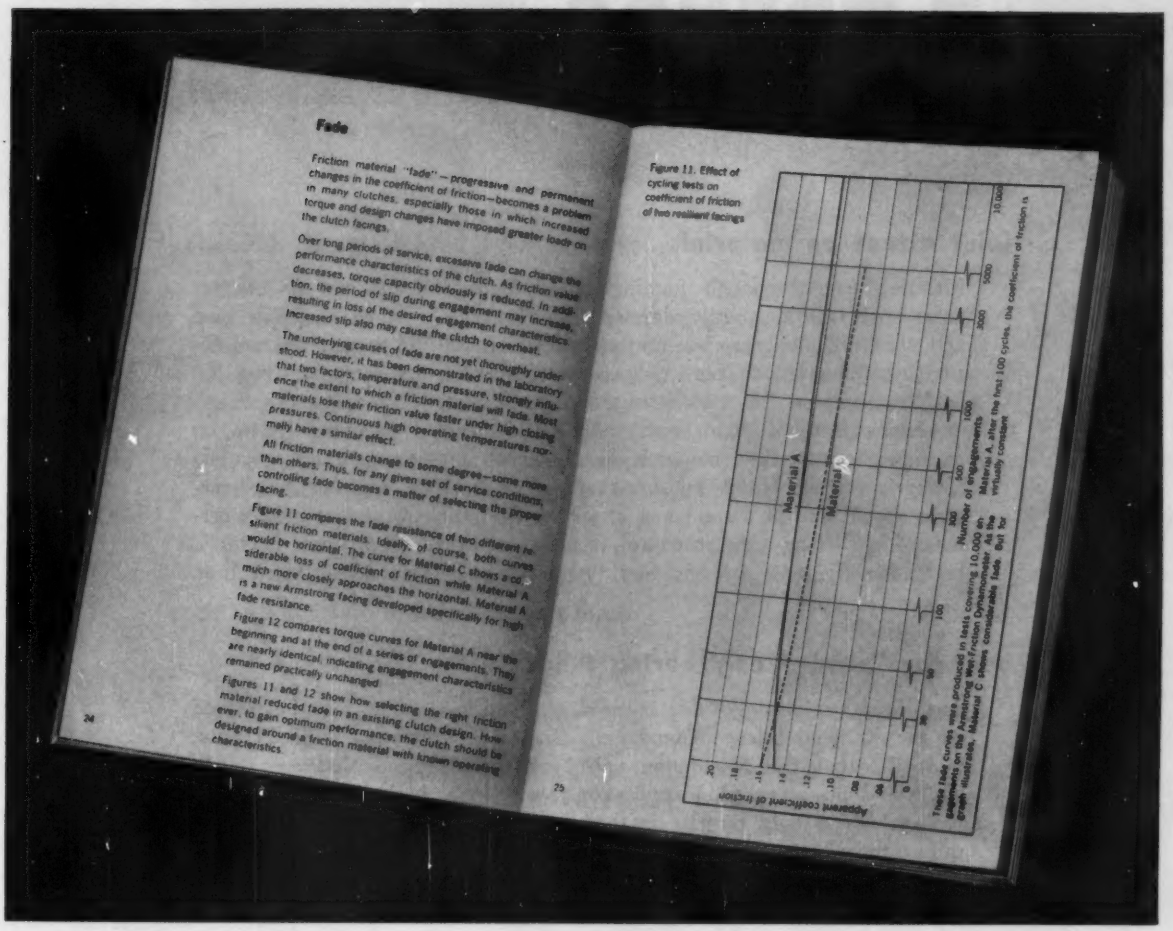
Fade
Friction material "fade"—progressive and permanent changes in the coefficient of friction—becomes a problem in many clutches, especially those in which increased torque and design changes have imposed greater loads on the clutch facings.
Over long periods of service, excessive fade can change the performance characteristics of the clutch. As friction value decreases, torque capacity obviously is reduced. In addition, the period of slip during engagement may increase, resulting in loss of the desired engagement characteristics. Increased slip also may cause the clutch to overheat.
The underlying causes of fade are not yet thoroughly understood. However, it has been demonstrated in the laboratory that two factors, temperature and pressure, strongly influence the extent to which a friction material will fade. Most materials lose their friction value faster under high closing pressures. Continuous high operating temperatures normally have a similar effect.
All friction materials change to some degree—some more than others. Thus, for any given set of service conditions, controlling fade becomes a matter of selecting the proper facing.
Figure 11 compares the fade resistance of two different resilient friction materials. Ideally, of course, both curves would be horizontal. The curve for Material C shows a considerable loss of coefficient of friction while Material A much more closely approaches the horizontal. Material A is a new Armstrong facing developed specifically for high fade resistance.
Figure 12 compares torque curves for Material A near the beginning and at the end of a series of engagements. They are nearly identical, indicating engagement characteristics remained practically unchanged.
Figures 11 and 12 show how selecting the right friction material reduced fade in an existing clutch design. However, to gain optimum performance, the clutch should be designed around a friction material with known operating characteristics.
24
25
Figure 11. Effect of cycling tests on coefficient of friction of two resilient facings
Material A
Material C
Number of engagements
Apparent coefficient of friction
These fade curves were produced in tests covering 10,000 engagements on the Armstrong Wet Friction Dynamometer. As the graph illustrates, Material C shows considerable fade. But for Material A, after the first 100 cycles, the coefficient of friction is virtually constant

New Armstrong technical manual on resilient clutch facings

Here's a manual of technical data that will help you improve clutch design and performance. All the information in this 48-page booklet was developed through engineering studies conducted at the Armstrong Research and Development Center. Case histories describing how clutches were altered to improve performance or lengthen service life in specific applications are included. And there are detailed discussions of and technical data on:

- Coefficient of Friction
- Frictional Stability
- Engagement Pressure
- Operating Temperature
- Fade
- Facing Density
- Clutch Chatter
- Many other aspects of clutch design, performance, and facing materials

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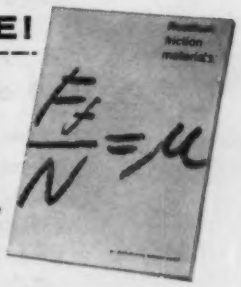

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joint attack on materials

Materials rugged enough for high-speed flight (in and out of the atmosphere) will apparently develop at a faster rate when materials men and structural designers learn to co-operate. An NASA research committee studying the problem points to two areas where faulty communication has held up progress: 1. Low-density structural materials (designers haven't emphatically stated their needs). 2. Development of meaningful data on mechanical properties (materials men concentrate too much on modulus-of-rupture tests). NASA suggests that experts in both materials and structures should launch a combined attack on the problems of sustained supersonic flight (long-term structural heating), re-entry (short-term heating), tanks for cryogenic storage, and "minimum-gage" low-density structures.

help for "needy" engineering fields

Specialized engineering fields in need of financial support may be rescued by the National Science Foundation. Dr. A. T. Waterman, NSF Director, told EJC that the Foundation will back those projects that are worthwhile and present a good application. He doesn't think that this includes projects whose only purpose is the development of a specific device, but rather those doing research that is fundamental to engineering progress. The boundary is hard to define, he agrees, but engineers understand it.

contract bidding spreads to consulting

Future consulting work for the Federal Government may be bid on a competitive basis if the Armed Services Committee has its way. In bill H.R. (12299), the committee suggests that proposals be solicited from a maximum number of qualified sources, for all contracts in excess of $2500. The National Society of Professional Engineers, urging the committee to amend the bill, says professional ethics prohibits consulting engineers from competing for contracts, so the government would deprive itself of the services of all engineers who abide by the code of ethics.

start of a new technology?

New developments in both optical and electronic equipment may result from intensified teamwork between specialists in the two disciplines. Physicists meeting recently at an international conclave agreed that optics and electronics are converging so fast that further progress may depend (at least in part) on a merger. Separated by a wide but comparatively inactive region of the electromagnetic spectrum (the infrared), light and radio frequencies vary by several orders of magnitude. Yet optical problems can now be solved by communication and information-transfer techniques. Equipment that might result from the merger includes an electronic random-scanning device that gathers data more efficiently than the human eye and an optical system that transmits information while holding down energy losses to values comparable with communication equipment.

research boom brings few patents

Despite a ten-fold increase in research activity over the last 20 years, patent applications have increased only about one-sixth. Admitting that they are puzzled by the lag, Patent Office officials suggest a number of possible causes. For example, with complex modern technology, an end product can be attained in so many different ways that no single development is worth patenting. Also, as patent literature multiplies, it has become increasingly difficult for inventors to determine just what is patentable. The third solution offered is that patents are being discouraged by the inhospitable attitudes of some courts.

spacemen face a housing problem

One of the problems that must be solved before man goes very far out in space is cabin design. But before reliable structures can be finalized, a new look at pressure-vessel theory will be necessary, NASA researchers report. Thin-wall structures, for example, made from high-yield-strength, low-elongation materials are still in the empirical-formula stage and fail-safe design methods are still shaky. In addition, tests are needed to determine the suitability of fabricated and processed material for pressure-vessel construction.

breakthrough or breakup?

Metalworking has had its share of spectacular developments during the last few years: Numerical control, explosive forming, and cartridge-actuated cutting tools, to name a few. A new proposal that would easily top any of these, however, is made by Commonwealth Engineering Co., Dayton, Ohio. The company holds a patent on a jet-powered press. Two opposed turbojet engines, mounted on the ram, drive the ram and platen up or down (presumably at subsonic speeds). According to Commonwealth officials, jet power would eliminate many of the complicated mechanisms usually associated with high-speed presses operating at high pressures. The firm intends to license the design.

no "gap" in education

The perpetual hassle over the state of engineering education in the U. S. is subject of a new and refreshing appraisal by one of the nation's leading educators. At the recent annual meeting of the American Society of Engineering Education, Frederick L. Hovde, president, Purdue University, said: "I do not share the view of many that we have made no progress in education. On the contrary, I think American education is constantly being improved at all levels. Anyone who follows the *Journal of Engineering Education* and studies the experimental work going forward in almost every institution in America cannot fail to be impressed with the thinking, imagination, and experimentation currently being applied to the problem of improving curricula, equipment, and methodology."

Aluminaut—Design for 3 Miles Down

Original purpose of the Reynolds Metals Co. project at Southwest Research Institute was to develop aluminum plate for ship and submarine hulls. But something else grew out of it: An aluminum submarine that can invade deep regions where steel subs can't follow. Reynolds' *Aluminaut* has been proved feasible and scale models are now under test. The full-size vessel will be completed in early 1961.

THREE men equipped with 3200 lb of scientific instruments will soon be exploring the bottom of the sea. *Aluminaut*, the research vessel designed to take them down, will permit more data to be gathered than ever before possible. A true submarine, the craft will cruise 15,000 ft below the surface, maneuver, and stay at that depth for long time intervals.

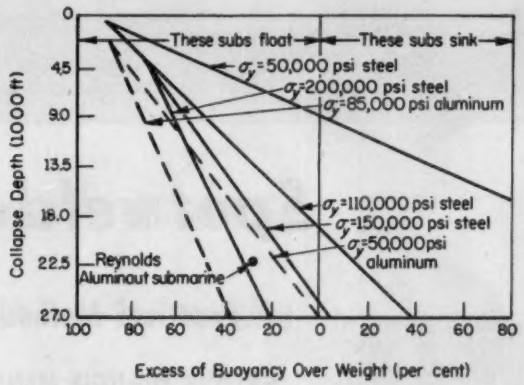
Design principles had to be developed and tested almost from scratch—rules for combat subs don't apply because these craft aren't able to dive beyond 5 to 10 per cent of *Aluminaut's* depth. Most significant mechanical property of the hull material was found to be yield strength; Young's modulus, important when considering shell instability, becomes less important with the thicker hulls associated with great depths. The true index of merit is tentatively defined by Dr. Edward Wenk Jr., chairman of SwRI's engineering mechanics dept. and one of the Navy's top authorities on deep-diving subs. It's the ratio of yield strength to density of the hull material.

To insure that *Aluminaut* will operate with a reasonable factor of safety (4:1) at 15,000 ft, SwRI engineers will test it at 17,000 ft, design it for a collapse depth of 21,000 ft. Several types of hull structures were investigated before a stiffened cylindrical hull was chosen. This hull, while not the most buoyant configuration, is satisfactory for the 15,000-ft operational depth, crew size, and instrument payload. In addition, the cylindrical hull eases fabrication problems, simplifies equipment location, and presents the crew with an "instinctively familiar" vehicle.

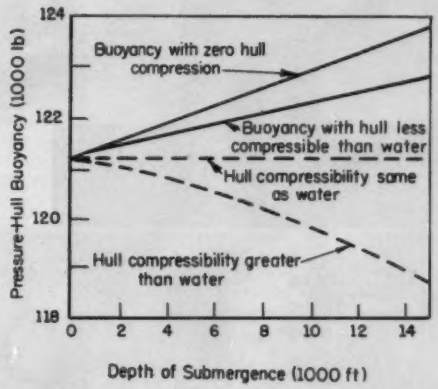
Why Aluminum?

Hulls able to resist the intense external pressure of a 3-mile water-column head (7000 psi) cannot be built of common high-strength steels, Dr. Wenk reports, because they would not be light enough to carry useful payloads. For such submarines, super-strength steels, fiber-glass reinforced plastics, titanium, and high-strength aluminum alloys are all superior. When the additional criteria of availability of required thicknesses, cost, fabrication ease, and ease of repair are evaluated, aluminum is the material showing the greatest promise.

The shipbuilding industry does not normally use aluminum hulls, but this may be due to tradition, Dr. Wenk continues. On the other hand, aluminum alloys have definitely found a home in the aircraft industry. Common in aircraft designed for subsonic flight, they're superior to other alloys in strength to-weight ratio. This same quality makes aluminum hulls feasible for deep-diving subs.



Weight characteristics for stiffened cylindrical hulls tell the story. Ordinate is depth at which water pressure will crush the hull; abscissa is excess buoyancy with water-ballast tanks empty. Experimentally, yield strength was found to be the most important variable. At the design collapse depth (21,000 ft) even steel of 110,000-psi and aluminum of 25,000-psi strengths are unsuitable. Aluminum alloy chosen by SwRI was 7079-T6 with a yield strength in excess of 60,000 psi, leading to a 31 per cent buoyancy—adequate for the load carried.

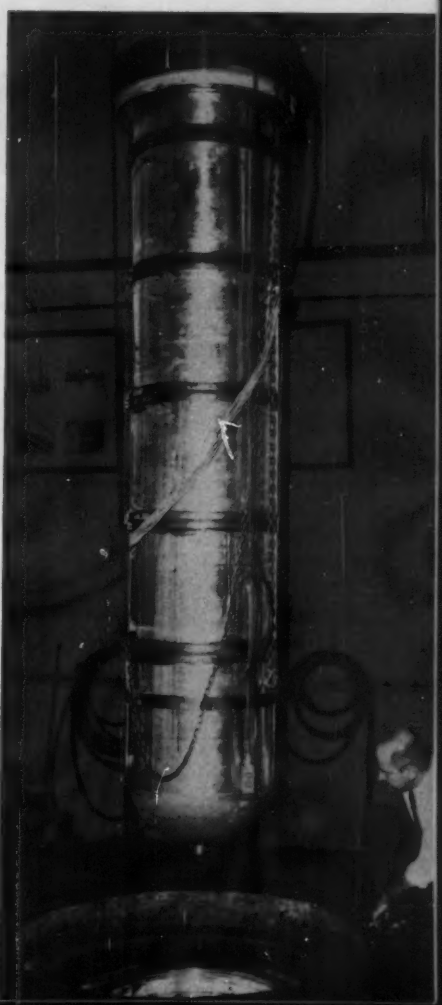


Pressure-deformation tests showed loss in volume of the compressed hull to be less than loss in volume of the displaced sea water. This is contrary to the case encountered with military (thin-walled) submarines; hulls of these subs are more compressible than sea water. The unexpected buoyancy gradient provides a stable descent system which conventional subs can't match: The boat, initially ballasted heavy, stops diving at an equilibrium depth. Conventional subs must pump out water to stop diving.

Design Features

Although hull strength was the knottiest part of the design problem, specified performance characteristics also had to be met. Most important were simplicity, safety, and reliability. The vessel was designed for manual operation rather than automatic, for 31 per cent excess buoyancy at collapse depth, and for a positive buoyancy gradient as the sub dives to greater depths.

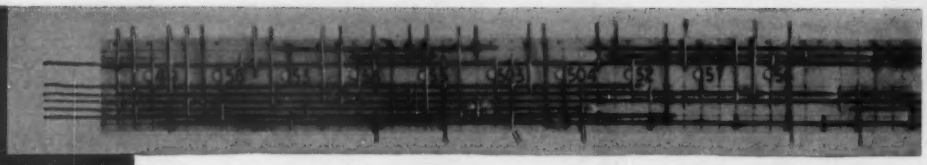
To permit hovering or following hills and valleys along the ocean bottom, a vertical propeller was added which can also be used for making emergency ascents. Depth seeking will normally be accomplished by the ballast method (to stretch out battery life), supplemented by forward propulsion at a down angle imposed by stern planes. Main propulsion system is a swiveling horizontal propeller and rudder which provide a directable thrust for short turning radius.



Quarter-scale model of **Aluminaut** awaits pressure testing to a depth of 21,000 ft. Strain gages are mounted inside to tip off areas needing additional reinforcement.

Built-in Capabilities: Better Than Needed

	Design Requirements		
	Bottom Dunking	Submerged Surveying	Aluminaut's Performance
Operating depth (ft)	15–18,000	12,000	15,000
Maximum speed (knots)	4	4	4–8
Range (nautical miles)	16	100	96
Crew	3	3	3
Normal payload scientific equipment (lb)	1500	3000	3200–6000
Power for instruments (kw-hr)	15	40	64
Vertical speed (fps)	3	3	11
Endurance (hrs)	20	24	36



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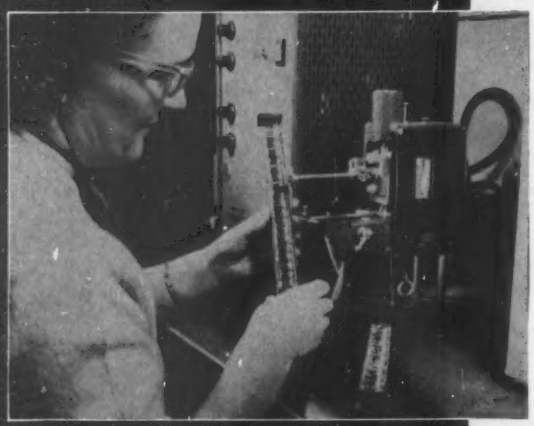
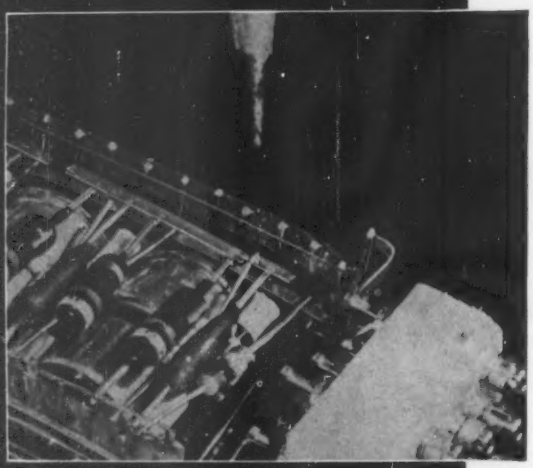


Logic wiring (above) is welded to a "stick" (left) in precisely programmed sequence that assures minimum heat transfer to components. Welding equipment is easy to operate, permits fast production of high-density packages.



More than 300 welds per cubic inch are made possible by optimum layout and logic wiring. Components are packed tightly in actual physical contact; bus wiring connects all repetitive sections of the circuit.

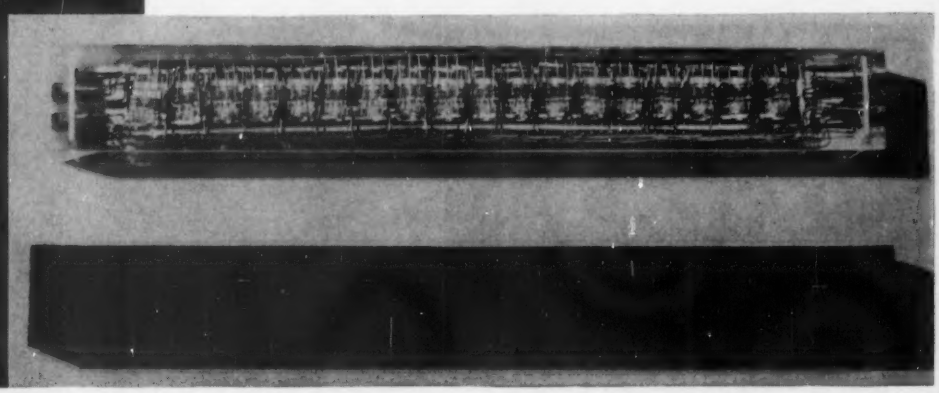
Finished module is potted in a wide selection of compounds, depending on specific environmental requirements. Where heat dissipation is a factor, a thin aluminum skin is molded on the outer surface of the package.

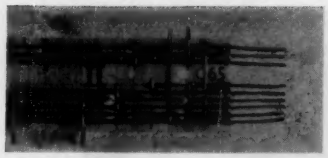
THE pursuit of miniaturization by the U. S. electronics industry has developed into one of the major contemporary engineering efforts. Depending on whose figures you accept, the size of an average black box full of average electronic components has been cut 20 to 50 per cent every year for the last 5 years. And more "startling breakthroughs" are being scheduled by industry.

The Right Connections

As is often the case in times of major progress, a fairly elementary factor emerges as a major stumbling block. With miniature electronics, connections are the bogie: Soldered joints must be between $\frac{1}{8}$ and $\frac{1}{4}$ in. from the component. And this basic requirement can easily double the volume of the package involved.

Attacking the interconnection problem directly (instead of waiting for smaller more exotic components) seemed a logical approach





Electronics

High-Density Packaging

to several manufacturers in the field. As a result of their research, tried and proved components, now available, are packed at twice the density previously thought feasible.

Welding Is the Key

Called 3-D, or Dense Welded Packaging, the novel technique consists of mounting standard miniaturized components, tightly together, in a three-dimensional mass and then joining the necessary leads by precision, electrical-resistance spot welding. The entire unit is encapsulated, after inspection, in a suitable potting compound. The completed module represents a rugged, reliable, high-density package.

Several manufacturers are now

The Big Squeeze

State of the art in high-density electronic packaging falls into one of three categories:

1—Radical packaging techniques, using standard miniaturized components.

2—Micro-module method — standard components are replaced by wafer form factors; wafers are stacked to form a complete unit.

3—Molecular electronics—complete circuit is "grown" on the surface of a single wafer of semiconductor material.

Of these three, only the first is now available. Micro-modules are just beginning to emerge from the laboratory, and molecular electronics is from three to five years away, with the military services at the head of the line waiting for operational hardware.

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constructing the welded package in the form of a "stick." Sticks, in turn, can easily be stacked or assembled into other shapes and forms.

Typically, a stick consists of several sub-units which have been joined together by accurate jigging and precision welding. At first glance, the profusion of components in such a package would indicate a maze of interconnecting wires. The opposite is true, however. The problem is minimized with a mesh of so-called "logic wiring," which consists of layers of fine wires insulated from one another except at the weld points. One mesh, mounted on either side of the stick, provides for optimum component layout, tack-weld points, and power-bus interconnections.

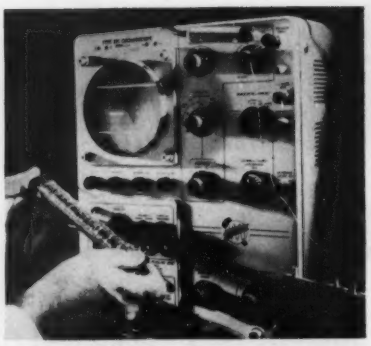
Variation of component leads in size and material presents no special welding problem. A common lead-joining material (flat nickel ribbon), developed recently, allows a variety of connections to be made with one setting of the welding equipment. Several manufacturers are looking further into the problem of optimum lead material, however. Nickel, stainless steel, and Dumet are being considered. Copper can be welded, but not too easily, particularly if it is coated with a residue of tin. Servo looks for component manufacturers to produce special items in the near future with easily weldable leads.

Potting Can Vary

Potting of the assembled unit offers no unique problems. Compounds to be used are determined by the specific environmental requirements. Low specific gravity encapsulants are now available which further contribute to the light weight of the finished module. Experimental studies are being performed on various potting compounds to investigate the effect of shrinkage on both the elastic and electrical properties of the embedded components.

Transfer of heat, generated within the potted unit, is one factor that must be seriously considered. With standard encapsulants, the temperature rise of components can be destructive. The method now used is to mount "hot" elements on an aluminum plate on one side of the module. Components can be potted with one heat-transfer face exposed. This face can then be mounted to an aluminum "cold plate."

While these techniques are valuable because they save considerable volume ordinarily reserved for heat exchangers, they do not attack the problem at the source, i.e., selection of suitable potting compounds with increased thermal conductivity. Research is expected to develop encapsulants that have improved conduction without adversely affecting other physical properties.



Dynamic testing of module is done prior to potting. Typical specifications: Vibration—50-g swept sine wave from 75 cps to 2000 cps in 3 minutes, repeated for 12 hours; shock—150-g, 11-millisecond half sine wave and 1000-g, 0.5-millisecond impulse; thermal—continuous duty up to 65 C for germanium circuitry (higher for silicon) at 5 to 95 per cent relative humidity.

Strangely enough, it has been found that potting components actually enhances heat transfer in certain applications. This is true especially for equipment used in space vehicles. Greater heat transfer can be accomplished in space by conduction through the potting compound than by radiation in a vacuum. Despite advances in heat-removal techniques, however, dense welded packaging has been applied mainly to low-power units such as digital circuits, multi-vibrators, converters, etc. Some progress has also been made in analog circuitry.

Not the Last Word

According to Servo, dense-welded packaging should not be considered solely as a competitor of other microminiaturization techniques. The logic wiring, for example, can be successfully applied to interconnection of other type micro-modules. In addition, the highly compact intramodular wiring can obviously be used to advantage wherever close tolerances prohibit use of soldering.

Servo engineers also acknowledge that the new technique is not the cue to cease further research in miniaturization. But high-density welding does offer immediate application, reasonable cost, and ruggedness in the miniaturization of off-the-shelf electronic components.

Weighing the Pros and Cons

In favor of spotwelding . . .

High densities—up to 200,000 components per cu ft are achieved, vs. 100,000 components per cu ft using the best soldering techniques.

Low initial investment—after operators undergo a brief training period in the use of the equipment, the price per package is competitive with standard production methods.

Reduced assembly time—spot welding is much faster than manual assembly of printed boards.

Clean, trouble-free connections—spotwelds are permanent and don't require special surface preparation.

Fewer human errors in fabrication—failure rate of soldered connections is 1:50,000; that of welded connections, 1:100,000.

Compact welding setup—the equipment is easy to maintain, has simple controls.

. . . Against

Many jigs and fixtures required for assembly.

Replacement of faulty parts is difficult due to the permanency of welded joints.

The "custom" approach to oil seal manufacture, pioneered by IPC, has resulted in some real off beat products.

None-the-less . . . they *work!* They suit the application *and,* in more cases than not, they have contributed substantially to cost savings.

When you're faced with a rugged problem involving oil seals, what synthetic compound comes to mind? How about case design? . . . friction? . . . torque? . . . shaft speeds?

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P-1

Pneumatic Monitor Tends Big Engines

System Sets Start-Stop Sequence, Pinpoints Shutdown Troubles

KANSAS CITY, Mo. — A pneumatic monitor, soon available, is capable of starting and controlling any internal combustion engine automatically and remotely. Originally developed for a gas-compressor installation, the versatile system is expected to have wide industrial application in automated processes.

Starting a high-horsepower engine, says W. D. Miller, vice president, Robertshaw-Fulton Controls Co., who developed the monitor, involves a number of separate but sequential operations. Taking the engine off the line involves the same steps, but not necessarily in reverse order.

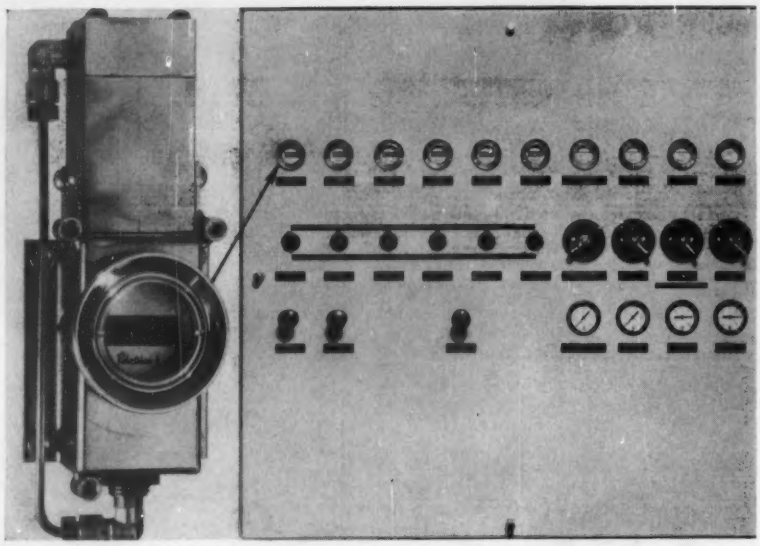
Given the remote "start" command, the system will first check conditions like temperature and pressure associated with an engine to determine if they are safe for starting. A remote-start buzzer will warn personnel that the engine is about to be started; positions of suction, discharge, and bypass valves connecting the compressor to the pipeline will also be checked. The next operation will start auxiliary equipment—air-intake filter screens, prelubrication pumps, jacket water-cooling equipment, etc. When all these mechanisms are operating properly, the control system will close the blow-down valve, and open the discharge valve.

The next step will admit high-pressure air to the engine. After the engine has been turned over to purge any residual gases, magnetos are ungrounded automatically to provide ignition. The fuel valve then opens, and with the engine running on gas, starting air and auxiliary prelubrication pumps are halted. The suction valve is opened, the bypass valve closed, and the engine is operating. Further adjustment to engine speed is provided continuously.

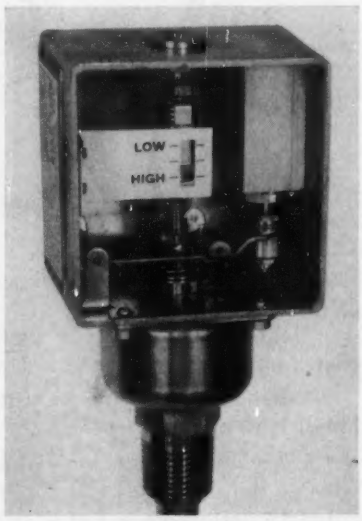
When an abnormal condition is detected, the control system will shut the engine down. Conditions are also frequently monitored which, although they will not damage the engine, should be corrected. Usually when an engine is stopped as a result of abnormal condition or malfunction, the number of possible causes means a considerable delay while the actual cause is sought. To shorten this lengthy investigation, the Robertshaw system provides a unique pneumatic-mechanical annunciator system.

So long as a measured point is within safe limits, the annunciator flags will show green. With the development of an unsafe condition, however, the indicator turns red. The system is so arranged that only the one red signal will show, although other measured variables may go to an unsafe condition as a result of engine stoppage. Accordingly, the reason for the shutdown is pinpointed.

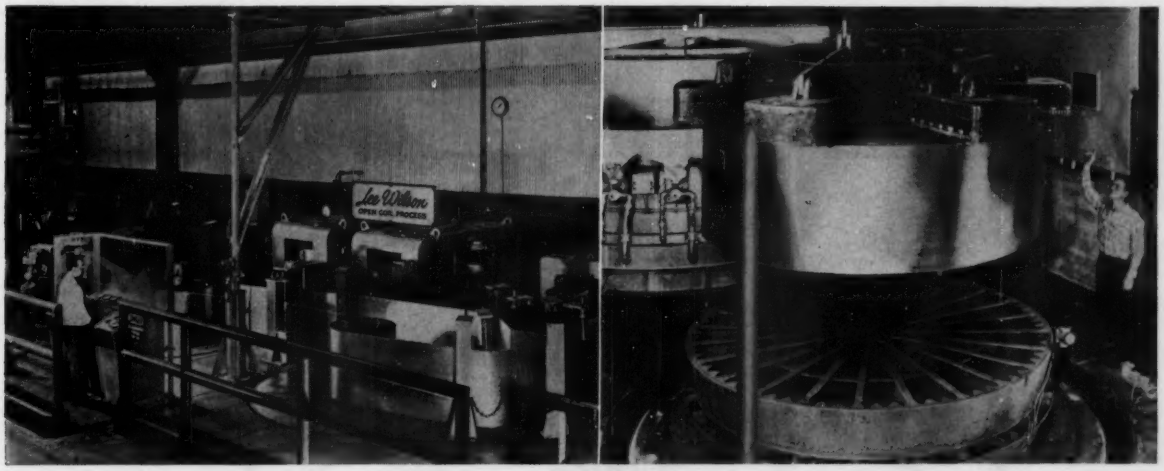
For points which require attention, but do not warrant engine shutdown, indicators can also be provided. When a condition outside preset limits occurs, the individual indicator shows amber to warn operating personnel.



Control panel of a typical pneumatic monitor, allowing direct reading of engine variables, has a line of annunciators. These fulfill two primary functions: If, say, cooling-water pressure falls below normal, the engine continues to function, but a pneumatic impulse causes the annunciator (left) to show an amber flag. But if lube-oil pressure drops below the safe level, the engine is halted, and the lube annunciator shows red to isolate the cause of the shutdown.



Typical temperature transmitter is vapor-pressure actuated (fail-safe). Information is relayed to the pneumatic control system from temperature and pressure transmitters, as well as from liquid-level, vibration sensors, etc., depending on the application. The engine is shut down, or a warning signal is displayed when any one of the monitored values exceeds its predetermined safe level.

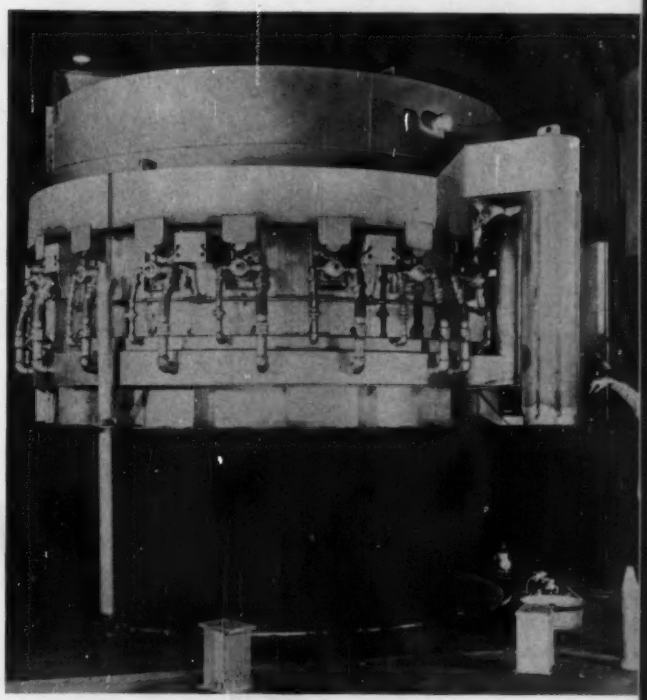


Coil-opening machinery (above, left) performs the first and key step in gas alloying. Huge round magnets (above) easily handle the opened coils. Hot gases simultaneously anneal and alloy the strip in special furnaces (below). Because heat, content, and velocity of the gases are precisely monitored, properties of the finished strip can be accurately predicted.

Ready commercially,

Gas Alloying

should lower the cost of several widely used steels



CLEVELAND—Steels suitable for "direct-on," one-coat porcelain enameling can be produced at a saving of $10 to $12 per ton, and a variety of other widely used steels may get even greater cost benefits from a new alloying and annealing process being adopted by all major U. S. producers.

Called open coil alloying and annealing, the process is a quick, relatively simple means of varying the chemistry of flat rolled steel during the annealing process. It was developed by Lee Wilson Engineering Co. Inc., Cleveland, who also designed the required production machinery.

As the name implies, the process involves the "opening" of a coil of steel prior to annealing. It's opened so that a nylon cord or metal strip can be inserted between each layer. Hot gases, directed at high velocity through the resulting air space, heat the coil quickly and uniformly to annealing temperature. Heating time is a fraction of that required by present methods, using "closed" rolls.

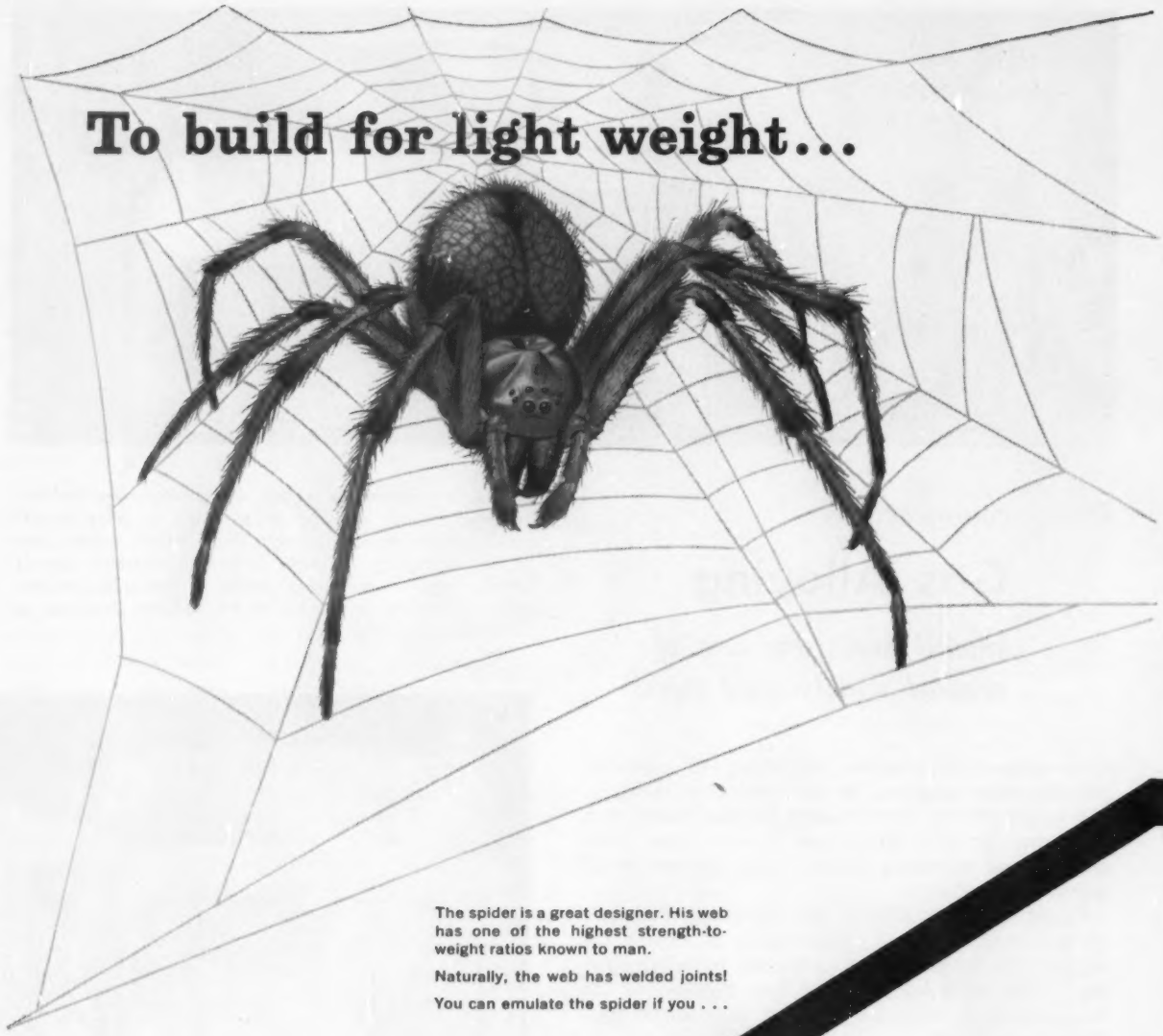
In addition to this quick-heat advantage, chemistry of the steel can be varied, according to the type of gas used and its heat, volume, and velocity. Thus, carbon, nitrogen, and other alloying elements that can be gasified are removed or added in precise quantities to regular commercial-size coils of rolled steel during the annealing process.

Because carbon content of steel can be reduced to much lower levels in the open coil method than is possible during melting, the blue ground coat, normally needed for enameling, is eliminated. First production runs of the process will thus be aimed at the home-appliance industry.

According to Wilson officials, "Steelmakers can produce non-aging steels at lower cost, and because of superior quality control possible through the new system . . . have found [that] they can produce better deep-draw rimmed steel, and a low-carbon sheet that becomes an excellent substitute for low percentage silicon steel.

"Almost every day our research lab or steel plant engineers where units are in operation come up with additional ways this equipment can increase production or develop better quality steels," Wilson reports.

To build for light weight...



The spider is a great designer. His web has one of the highest strength-to-weight ratios known to man.

Naturally, the web has welded joints!

You can emulate the spider if you . . .

design for welded steel

STEEL'S inherent strength and rigidity make it a natural choice for the selective designer who wants to save weight. Combine with steel the advantages of arc welding and you have a team that's hard to beat.

Welding's ability to join parts of the exact shape and section eliminates the tendency to overdesign. Stiffeners can be placed where needed without adding excess weight. Fabrications of welded steel save money at the design level, and in manufacturing, and in shipping.

The next time you start to design a cast iron part, stop and consider welded steel. For ideas on how you can do it easily, call your LINCOLN Field Engineer. He's a specialist in arc welding applications.

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LINCOLN WELDERS

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Nested Cores Shave Transformer Size

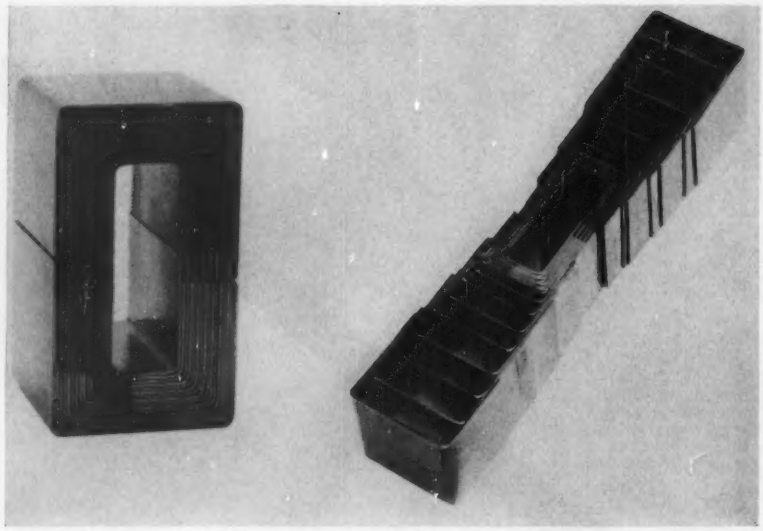
NEW YORK, N. Y.—A fundamental change in design allows smaller and lighter transformers to be produced without loss of operating efficiency.

The change consists of throwing out the standard EI form of shell transformer core, replacing it with a "Flexi-core." Developed by Sylvania Lighting Products, the new core is 2 to 30 per cent lighter than those now in use, depending on the electrical requirements. It is made up of nests of steel laminations, bent into "U" shapes, two such nests being fitted together and welded to form a rectangle. Strips that form the laminations are of different lengths, so that intermeshing of the strips occurs when two U's are brought together.

To the designer, there are two primary advantages: First, because the new core is bent, not stamped, grain of the metal is along its length —always in the same direction as the path of the magnetic flux. Thus, flux resistance is reduced so that a thinner core will do the same job as a thicker EI core.

Further, the core can be built in a virtually unlimited number of shapes and sizes. The designer has more flexibility than ever before—he can specify a core to exactly fit the job, rather than having to adapt the transformer to a standard die size used to build stamped cores.

For the past few years, more and more use has been made of electronic computers for designing transformers. The computer results, however, could never be followed exactly. Flexibility of the new core permits computer data to be utilized directly in manufacturing.



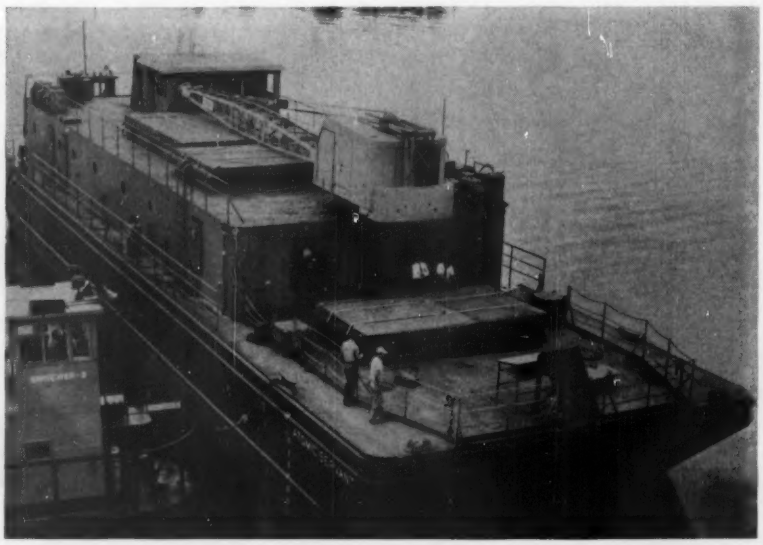
A formed core that is potentially applicable to almost half the transformer designs now in use may take the place of conventional EI stampings. The new core is a nest of steel strips laminated into U shapes from a continuous roll. For a shell transformer, two nests of strips are fitted together to form a rectangle, and two rectangles, welded together, form the EI shape of the shell core.

Sidekick for Savannah

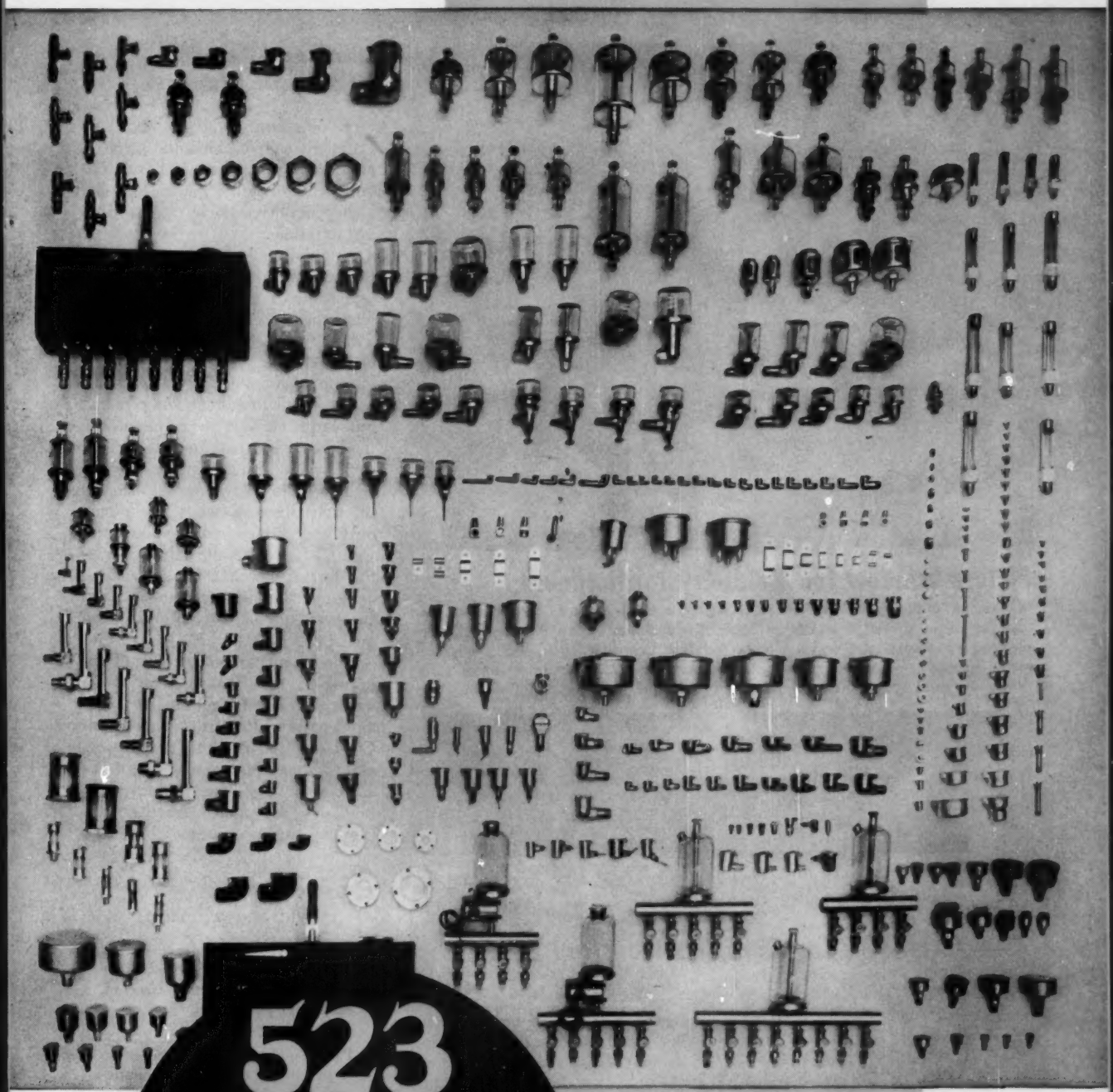
HOUSTON, TEX.—Taking no chances with its dangerous radioactive cargo, the barge *Atomic Servant* has collision decks an inch thick. Designed to take care of *N. S. Savannah's* nuclear reactor, her cargo consists of highly irradiated fuel elements and nuclear wastes. Built by Todd Shipyards Corp., and recently launched, she is scheduled for a series of extensive tests with the *Savannah* later this summer.

Of the *Atomic Servant's* 760 tons, some 250 tons are lead—her fuel pit has a 12 in. thick lead lining, and the liquid waste and processing tanks are also lead lined.

The barge's 10 to 15 man crew pass through check-out monitors every time they leave contaminated areas, and the radiation film badges that they wear are checked periodically during the day.



Cooling for ninety days, spent fuel elements from the N. S. Savannah's reactor will lie in a lead-lined fuel pit aboard this barge. Nonpropelled, 129 ft long and weighing about 760 tons, she will dispose of irradiated material at sea.



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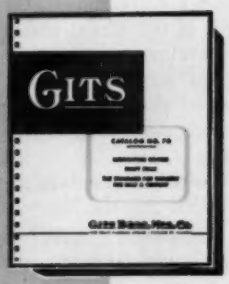

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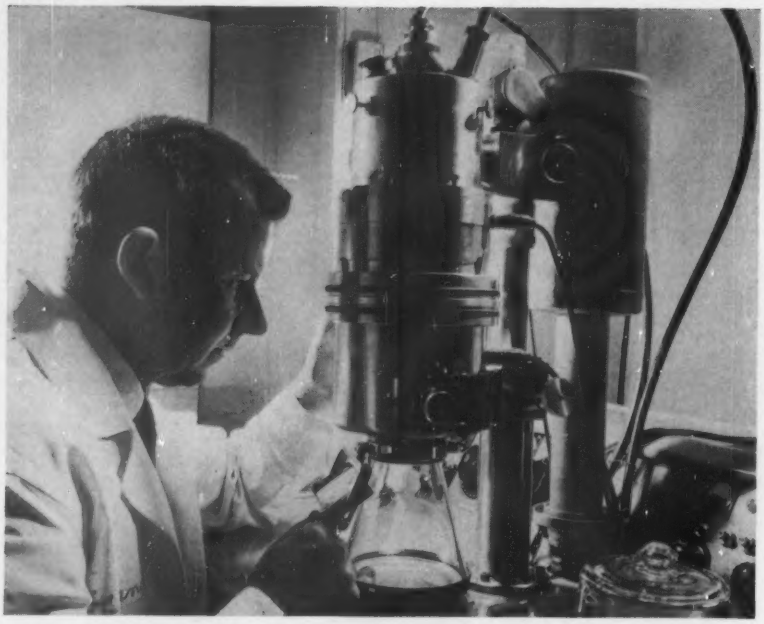


Picture Window for Metal-Crystal Hothouse

Microscope with a built-in furnace is being used to observe the changes that take place in a metal crystal at high temperatures. The thermionic emission electron microscope at General Motors Technical Center, Warren, Mich., magnifies metal samples up to 3000 times. "Live" views of microstructural changes occurring in a steel sample (below) range from 1800 F (left) to 1950 F (right).

ASW Techniques Lagging, Says Industrial Team

ROCHESTER, N. Y. — Complacent feelings that the United States is safe from attack by hostile submarines operating in American waters should be quickly dispelled. An antisubmarine warfare committee of industrial experts has recently completed a two-year study of Navy's ASW punch. Given full details of the threat posed by Russian submarines armed with intermediate-range ballistic missiles, they concluded that such vessels could deliver a paralyzing attack on the nation.

To reduce the danger, they recommended that the Navy:

- Centralize ASW information, eliminating repetitious data.
- Design and build special underwater search and reconnaissance vehicles.
- Reduce shipboard - maintenance items, such as torpedoes, by using more prepackaged weapons.
- Develop longer, deeper underwater test ranges to help fulfill the "crying need for oceanographic information."

The committee added that it believed ASW posed the most difficult technological problem ever faced by the Navy. Reviewing organizational setups, the committee approved but felt that ASW techniques were falling behind. Greater flexibility in research and development contracts must be allowed, it was felt, and the committee asked for more feasibility studies to insure that specifications for a new weapon were as advanced as possible.

Microcrazed Ceramic Molds Better Castings

PORT WASHINGTON, L. I., N. Y.— Complex shapes, smooth surfaces, and sound sections—hitherto obtained by lengthy machining—are being produced by a radical casting technique.

Originally developed by two British scientists, the method depends on a unique mold that exhibits a phenomenon called "microcrazing". This is a three-dimensional system of tiny cracks that develops throughout the mold material.

Too small to admit molten metal, but large enough to accommodate the thermal expansion of the ceramic mold, these fissures are the right size to allow gases to escape through the mold walls. Thus porosity and surface inclusions are prevented. An economic advantage to the foundry is that molds can be designed without the massive risers characteristic of conventional sand molds.

The greater intricacy of detail obtained in the final product is an important advantage of the Shaw mold. Shaw Process Development Corp., which uses the process, explains that this results from the "stripability" of the rubbery, unfired ceramic mold. Another advantage is that hot metal can be poured directly into the cold mold.

The Shaw Process

Mixing—A liquid binder, to which a gelling agent has been added, is mixed with a proprietary blend of refractory powders to produce a creamy slurry.

Pattern—The slurry is poured over a pattern of wood, metal, plastic, etc. It is then allowed to gel in about 2 to 3 minutes.

Stripping — The gelled refractory mass is stripped from the pattern by hand or mechanically.

Burnoff—The mold is ignited. It burns until all volatiles are consumed. This sets up the "microcrazed" structure.

Baking—The Shaw Mold, now immune to thermal shock, is placed in a high-temperature oven until all moisture is driven off.

Casting—Cope and drag mold pieces are assembled along with any necessary cores and the metal is poured.

Circle 417 on Page 19→

custom tailoring costs less than "ready-to-wear"

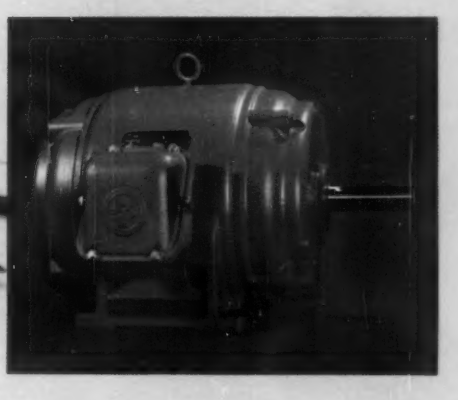
Buying an electric motor with "ready-made" insulation can be a costly luxury.

Motor operating conditions vary so widely throughout industry that Fairbanks-Morse insulation systems are *tailored* to actual operating conditions . . . not *standardized* to "the average".

"Ready-made" insulation systems are an "across-the-board" compromise with *average* operating conditions. When *your* case is the all-too-frequent exception, the compromise is costly.

Even in "hard to fit" cases we build motors rated, dimensioned and insulated to furnish unfailing power. Insulating materials are carefully tested, selected, treated and prepared so that insulation as well as motor enclosure is *matched* to the job. Entire insulation system is custom tailored to meet emergency overloads, temperature extremes, corrosive atmospheric conditions . . . whatever combination of factors affects motor life and performance of your *specific* operation.

This *flexible* application of varied insulating materials and processes "pays off" in low maintenance, uninterrupted production, prolonged service.



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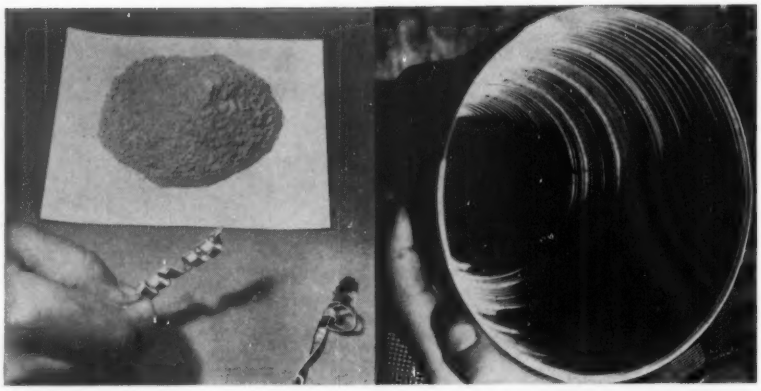
Ductile Composite Metals Sintered in New Process

YONKERS, N. Y. — Ductile, homogeneous composites of metal and oxides are being produced by an advanced powder metallurgy technique. Hitherto, combinations of rare-earth oxides with metals have produced only brittle, almost unworkable alloys.

With the new technique developed by the Sintercast Div., Chromalloy Corp., alloys are produced whose properties equal or exceed those of cast and wrought alloys. The composites are produced from elemental powder mixed by a solid-state process and sintered at a temperature lower than the melting point of any constituent. Extremely close composition specifications are possible, since there is no volatilization or segregation. The mixture is never molten, so that there is no absorption of foreign matter from the atmosphere or mold walls.

The technique permits closer regulation of particle size and dispersion than conventional casting procedures, and it can be used where two constituents are mutually insoluble. Sintercast is presently producing "Binal"—boron dispersed in aluminum—which is ductile, nonporous and strong, for use as a nuclear poison.



Twisted and bent, flexible enough to be wound into a coil, "Binal" shows itself to be almost as ductile as pure aluminum. A composite of boron and aluminum produced by an advanced sintering process, Binal is made from powder hydrostatically compacted and subjected to low heat. The production technique is equally applicable to many other matrix metals.

Electrifying an Import

A 9-in. diameter motor is the "engine" in this modified Renault Dauphine. The specially designed 72-volt traction motor has high torque per ampere characteristics and special high-temperature insulation. Speed adjustments are presently made by changing the armature voltage, but General Electric Co., Erie, Pa., is researching a new stepless electric control for future models. "Henney Kilowatt" can travel at 35 mph fully loaded for 40 miles, if run constantly, or as far as 60 miles if operated more slowly and with frequent stops. Engineered by Eureka Williams Co., the 2245 lb car is being sold exclusively to the utility industry.

New Mathematics Needed For Computer Programmers

ANN ARBOR, MICH. — Advances in high-speed computer technology have been "just unbelievable" in the last twenty years, but better methods of programming and more assistance from the mathematician are needed.

Dr. H. H. Goldstine, director of IBM mathematics research, noted in concluding a series of computer courses at the University of Michigan, that the computer field had grown from 25 people to "hundreds of thousands." At the same time, he said, computer memories have increased from 20 words to tens of thousands.

But while advances have been made in computer capability, programmers have increased their speed only ten times. There is no theory to help in the programming field, and none seems imminent. In fact, the mathematics of the type necessary to aid programmers has advanced not at all. Numerical analysis methods have not changed since the days of Gauss—who died in 1855.

One reason for the lack of mathematicians' interest is that computers have been of very little help to the pure mathematician. They limit him, in fact. For instance, computers limit a problem to a finite number of steps. Furthermore, results are limited by the finite (although large) number of decimal places provided by a computer.

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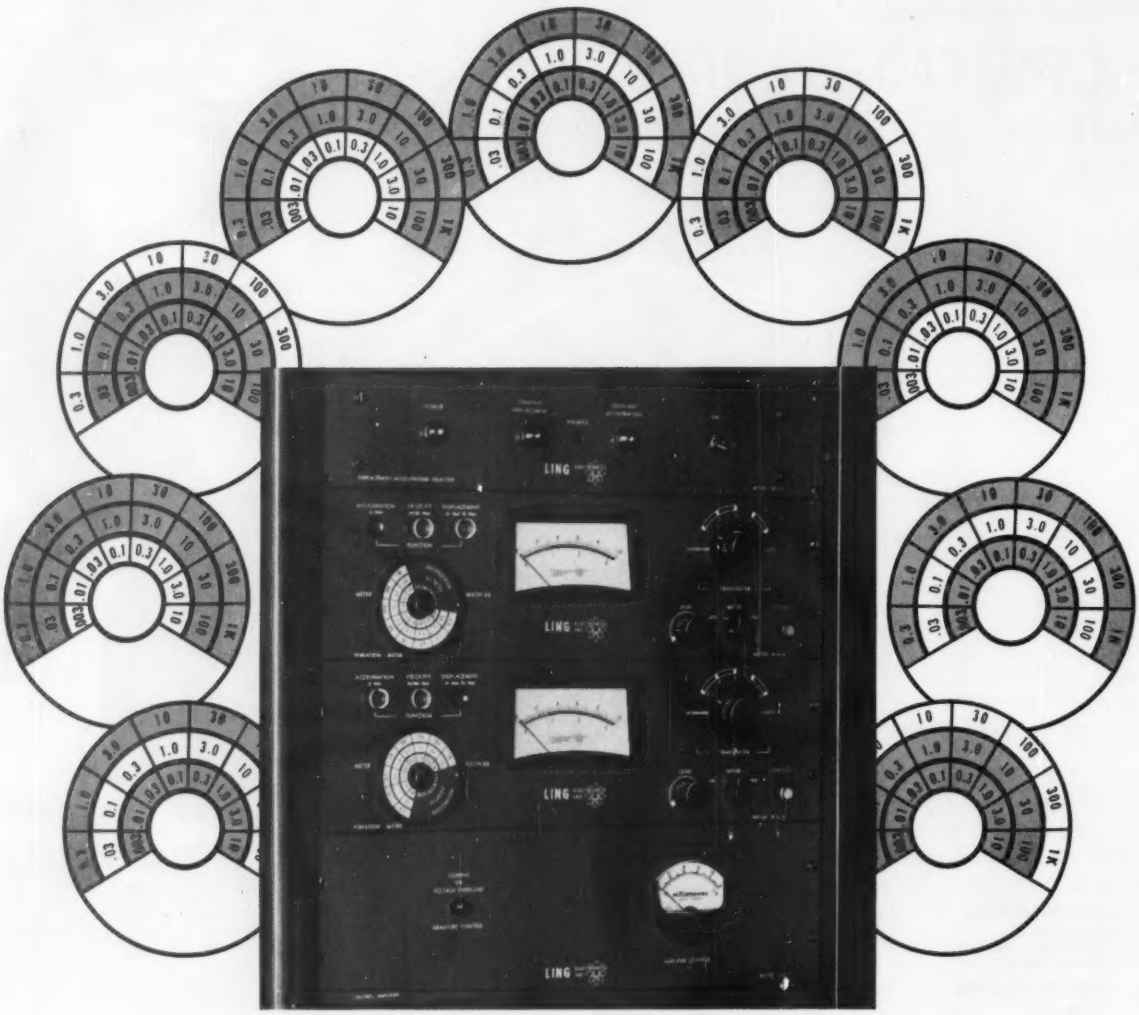

AUTOMATION IN VIBRATION–Vibration variations of 1000 to 1 automatically controlled by NEW LING S-14 SERVO

Ling introduces another advance in vibration testing—a new electronics servo system that offers a dynamic range of 60 db, plus remarkable accuracy and ease of control. This new variable response S-14 Servo System performs automatically, while frequency cycling with a sine-wave signal source. It simultaneously monitors any two values of acceleration, velocity or displacement, then automatically selects the larger as the controlling signal, and maintains it constant. Automatic thumpless transfer between the control functions takes place—you simply set the desired limits on the corresponding vibration meter. Reaction time is inversely proportional to frequency, and as a result, controlled levels of plus or minus 3% are attainable over a wide dynamic range. Like other Ling designs, the S-14 is flexible—the basic system can be expanded to handle 4 separate signals, or to permit automatic control from 3 or 4 control signals. For details, write Dept. **MD-4** at our Anaheim address.

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LING ELECTRONICS

The flexibility of the S-14 Servo System at the left, is just one more example of the way Ling design anticipates your needs of the future. Since the complete control package is made up of separate components, the system not only meets your present demands, but can readily be expanded. The basic two-level system includes 2 vibration meters, 1 control amplifier, 1 control selector,

By simply adding the appropriate number of meters and selectors, the system can be expanded to meter 3 or 4 separate signals with automatic transfer between control functions.

Transfer between control functions is handled by an electronic switch which automatically selects the correct crossover point. You merely set the desired limits on the corresponding vibration meter, shown close-up in the photo below. No thumps or other low frequency transients mar this smooth transfer.

This kind of flexibility, precision control and ease of operation begins with thoughtful consideration of basic operating requirements. And whatever your needs in high-power electronics—for vibration testing, acoustics or sonar—you'll find you can rely on Ling Electronics for the thoughtful design that leads to practical advances.

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HIGH-POWER ELECTRONICS FOR
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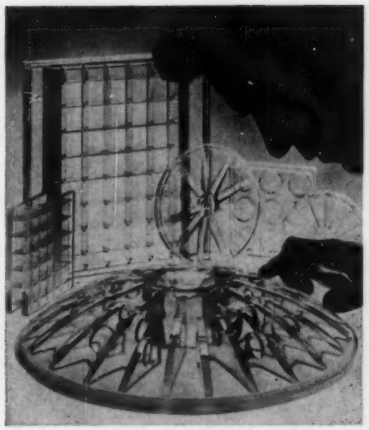


Glass Sandwiches For Space

Mirror blanks, made by an unusual sandwich technique, will find use in aerospace telescopes. Corning Glass Works claims that mirror systems using its blanks are only half the weight of previous types having the same surface area. The mirrors are made of two fused silica plates separated by walls or tubes of the same material that have been sealed to the plates under intense heat. Because of the almost zero thermal expansion of fused silica, no distortion occurs, even under sudden or extreme temperature changes.

Test for Professionalism and More Rhubarb on Unionism

WASHINGTON, D. C.—Are professionalism and unionism compatible? Are engineers professionals? The arguments rage on.

Whatever is decided, and whatever is done about it may influence not only the 750,000 engineers in American industry today, but perhaps the future course of the whole nation.

Willing to sacrifice?

Engineers generally consider themselves to be professionals, but in fact, are they? Most of them want the status and respect accorded professionals, says J. J. McKetta, of the University of Texas, but few are willing to put themselves out to attain them.

He suggests a simple test for picking out the real professionals. Arrange the following list of personal goals in the order that matches your own:

1. Performance of creative work
2. Achievement of professional standards
3. Security of a steady job
4. Use of talents to benefit society
5. Receipt of an adequate salary
6. Progress as an individual

According to McKetta, ethical standards dictate that the goals of a professional should be in the order 4, 2, 6, 1, 5, 3. But in a survey taken of 1300 technical employees, the order of importance listed was 6, 5, 1, 3, 2, 4.

He points out, however, that in industry professionalism is a two-way street. Firms that want professional performance must establish suitable conditions for it to flourish. He recommends adoption of NSPE's "criteria for professional employment of engineers."

Not compatible?

NSPE continues to claim that unionism is incompatible with professionalism—inasmuch as unions place job security and salary above personal duty and service. But around the country, 40,000 engineers think otherwise. Nearly 1000 members of the Sperry Engineers Association recently voted in favor of affiliating their union with the AFL-CIO; voting had been delayed for months by strong controversy. The company has appealed for a court injunction against the affiliation.

Engineers at Western Electric plants all over the country recently rejected representation by their Council of W. E. Professional Employees. Rejection isn't as simple as it at first appears, however. The union was first certified in 1952 and negotiated three successful one-year contracts. While negotiating a fourth, it balked at the company's meaning of the word engineer. Western Electric claimed that anyone doing professional work was, per se, a professional, but the union insisted that management was assigning subprofessionals to professional work. Behind the impasse:

The union's desire to keep itself composed entirely of engineers.

How professional?

At the same time, the federating group, Engineers and Scientists of America (ESA), was also being agitated by members' split views on professionalism. In May 1957, ESA ruled that new affiliated groups must be all-professional, and that technicians in already-affiliated groups could no longer vote on ESA matters. Four important affiliates promptly deserted, cutting ESA in half. At Western Electric, the union, having made no progress with management, decided to ask the National Labor Relations Board to certify a new bargaining unit, one from which technicians (by union definition) would be excluded. To do this the Council had to de-certify itself—hence the election.

The National Society of Professional Engineers, before the vote said, "If the union wins it will be a shot in the arm for all engineer unions. If it loses, it will virtually spell the end of engineers' unions in this country."

After the vote, the union "congratulated" the company on its successful campaign to "deprive professional engineers of their constitutional rights under the Taft-Hartley law."

And in a case before the NLRB, a split decision was reached on the inclusion of draftsmen in a production union in Peru, Ind. Some panel members reasoned that drafting does not require the exercise of specialized training. The dissenting opinion, in accord with the Western Electric decision, said that work performed, not personal qualifications, determines employee status.

Researchers Progressing Toward Ultimate Auto Tire

AKRON—The tire of tomorrow will make today's tires as obsolete as carriage wheels, and it may soon evolve from research and development work with five synthetic fibers. Goodyear's quest for smooth and quiet riding tires with exceptionally long life has led down some new alleys lately, says Dr. R. P. Dinsmore, vice president in charge of research.

New fibers have tremendous potentials in terms of what they allow to be built into tires. For example, one fiber (a member of the polyamide family) has a melting point of 600 F, instead of the 482 F for the fiber used in today's premium tires.

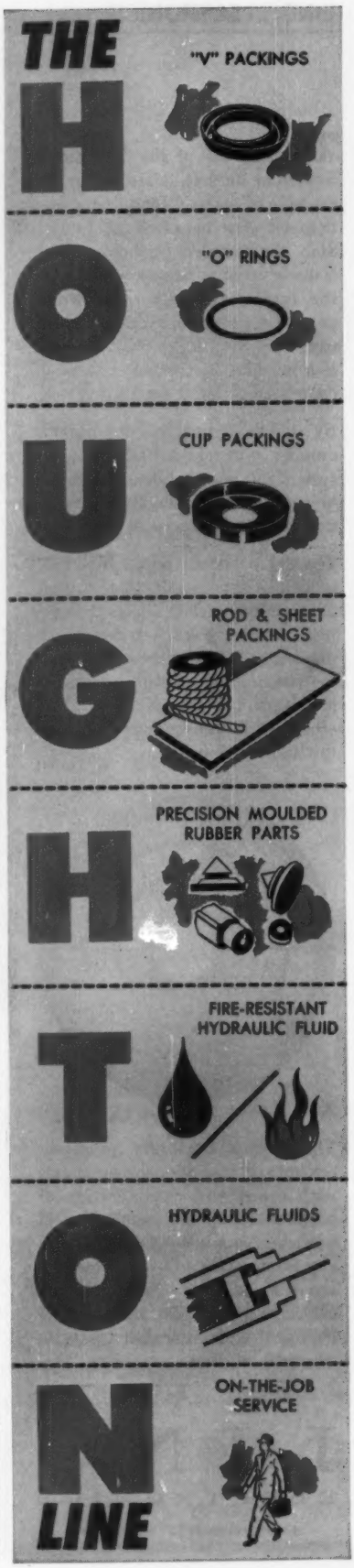
Fibers and fabrics now used are adequate, but they won't do as auto speeds go up. Future tires will need better uniformity and dimensional stability for smoother running (produced in the lab with three polyester fibers), better resistance to separation from heat and speed and better adhesive properties (obtained experimentally with Vinal, a Japanese polyvinyl), and higher melting points. Problems haven't all been solved yet but research results are promising, Dinsmore reports.

ASTM Standards Called Help for Undeveloped Areas

ATLANTIC CITY, N. J.—One of the most effective ways for Americans to provide technical assistance to underdeveloped countries is to push for universal adoption of ASTM standards. Much of the wealth of information contained in the standards is not available in any other form, F. L. LaQue, retiring president of the American Society for Testing Materials, reported recently.

"In the field of materials, the 14,359 pages in the ten volumes of ASTM standards comprise the greatest concentration of immediate and practically usable information that it would be possible to furnish anyone needing such data . . . In most cases, no further work or search for data should be required to characterize a material needed for some specific purpose, whether it be concrete for a wall, steel for a bridge, or fuel for an engine."

Best way for a foreign purchaser of U. S. materials to describe what he wants and be sure of getting it is to use an ASTM standard, Mr. LaQue continued. Benefits are obvious to both buyer and seller: Greater use of the standards should go a long way toward improving the demand for high-quality mate-



New multi-purpose *Rex-Syn* offers manufacturers of original equipment a unique combination of economy and efficiency in moulded cup packings.

After more than two years of extensive laboratory and field testing, Rex-Syn (plastic-rubber) packings are proving ideal for actuating equipment where pressures are medium to high—where pH extremes must be considered—where long storage life is important—and where low first cost is a definite factor.

Other important Rex-Syn features: extremely low friction rating—"equal to the best on the market"; a wide temperature range (0°F. to 212°F.); high resistance to abrasion (outlasts other elastomers 2 to 1); high tensile strength (rated at 3200 psi.); compatibility with a variety of media—air, oil, acid and alkaline solutions and water base hydraulic fluids.

Rex-Syn packings are available in all standard cup sizes from 1″ through 6″ O.D. For a copy of the informative Rex-Syn folder write E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.

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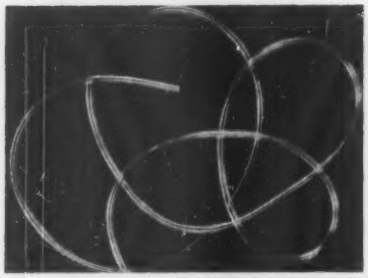

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CYCLON 310 crystal clear for visual inspection, resists most corrosives at temperatures from 0°—175°F, thirty-seven sizes including 6 wall thicknesses.

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MUNRAY POLYETHYLENE — recommended for low pressure, low-cost applications such as instrument tubing, colored for coding, takes standard fittings.

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rials and in counteracting the first-cost appeal of lower-grade materials of uncertain and undefined qualities.

Before the standards find wide use abroad, they will have to be translated into other languages. Steps are already underway to do this for Latin America, and the outgoing president urged that the matter be pursued on an international scale. The Society now has members in more than 50 countries, and in 1959 it received 9000 orders for publications from more than 65 foreign countries.

Meetings and Shows

Aug. 8-12—

American Institute of Electrical Engineers. Pacific General Meeting to be held at the El Cortes Hotel, San Diego, Calif. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Aug. 14-17—

National Heat Transfer Conference, sponsored by the American Society of Mechanical Engineers and the American Institute of Chemical Engineers, to be held at the Statler Hilton Hotel, Buffalo. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

Aug. 16-19—

Society of Automotive Engineers Inc. National West Coast Meeting to be held at the Jack Tar Hotel, San Francisco. Further information can be obtained from SAE, 485 Lexington Ave., New York 17, N. Y.

Aug. 23-26—

Western Electronic Show and Convention to be held in the Memorial Sports Arena, Los Angeles. Sponsors are the Western Electronic Manufacturers Association and the Institute of Radio Engineers. Additional information is available from Wescon, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Sept. 6-16—

Production Engineering Show to be held at the Navy Pier, Chicago. Further information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 6-16—

National Machine Tool Builders Association. Machine Tool Exposition to be held at the International Amphitheatre, Chicago. Additional information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 7-9—

Joint Automatic Control Conference to be held at Massachusetts Institute of Technology, Cambridge, Mass. Sponsors are Instrument Society of America, American Society of Mechanical Engineers, American Institute of Electrical Engineers, Institute of Radio Engineers, and American Institute of Chemical Engineers. Additional information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 12-15—

Society of Automotive Engineers Inc. National Farm, Construction, and Industrial Machinery Meeting, including production forum and engineering display, to be held at the Milwaukee Auditorium, Milwaukee. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Sept. 15-16—

American Society of Mechanical Engineers. Engineering Management Conference to be held at the Morrison Hotel, Chicago. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 18-21—

American Society of Mechanical Engineers. Petroleum - Mechanical Engineering Conference to be held at the Jung Hotel, New Orleans, La. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 19-20—

Steel Founders' Society of America. Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from society headquarters, 606 Ter-

Revere helps "fit the metal to the job"

AND A MAKER OF MEDICINE CABINET MIRROR FRAMES SAVES $10,000 A YEAR

As a result of a suggestion made by one of Revere's Technical Advisors, a maker of mirror frames for medicine cabinets has saved $10,000 a year on polishing costs alone. The suggestion was that, by changing to a brass of different grain size, the manufacturer might be able to save money on polishing costs and at the same time improve the quality of his product. (The 90° bend to which the mirror frames are subjected also had to be taken into consideration.)

Samples were made using a Revere Brass Strip with a smaller grain size as recommended by the Technical Advisor. Tests showed that, as a result of the change the manufacturer was able to realize a saving of 17¢ per mirror frame on polishing costs alone, with no increased costs in other operations, including the 90° bend. Based on the saving per frame this manufacturer has saved $10,000 per year for the past 4 years!

Here is still another example of how Revere's Technical Advisory Service working with the customer and the mill helped "fit the metal to the job," thus saving the customer money as well as improving product quality.

Why don't you take advantage of the extensive knowledge of Revere's Technical Advisory Service in "fitting the metal to the job?" It's entirely possible this service can save you money . . . help improve the quality of *your* product.

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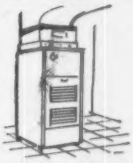
• A single TORQ SYNPRO-TEX governor cycles an automatic washer during spin-dry to less than 1G to more than 1G to balance the load, get clothes drier and make the wash "fluffy".

• A TORQ MULTITECTOR practically runs a diesel engine. It cuts out cranking motors, engages and disengages cooling circuit, provides fuel requirements at different speeds, then signals full speed.

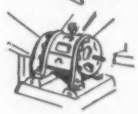


• TORQ governors relate fuel supply to air supply in power gas burners. A single governor will purge the combustion chamber, then turn on the gas, and during operation if blower falls below required speed for any reason, the governor shuts off the gas.

• In event of overload on a saw mill, due to dull blades, a TORQ governor causes the cutting blade to be withdrawn before damage can occur.

• On electronic equipment blowers, a TORQ governor will cut the equipment out of the circuit in event of blower failure, to protect expensive electronic components against overheating.

• Conveyors are automatically shut off if they fall below predetermined safe speed.



• TORQ governors make an ideal plugging switch to cut out the motor at low speeds close to zero before motor reverses.

• On truck refrigerators, TORQ governors maintain proper voltage and frequency output from the alternator by shifting it through a solenoid actuated transmission at pre-calculated truck engine speeds.

If your device employs a rotating shaft, a TORQ governor can sequence it, control it, provide signals, or monitor it for safety at one or many speeds from zero to more than 15,000 rpm.

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minal Tower, Cleveland 13, Ohio.

Sept. 21-23—

American Society of Mechanical Engineers—American Institute of Electrical Engineers Power Conference to be held at the Bellevue-Stratford Hotel, Philadelphia. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 26-29—

American Welding Society. Fall Meeting to be held at the Penn-Sheraton Hotel, Pittsburgh. Additional information is available from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 26-30—

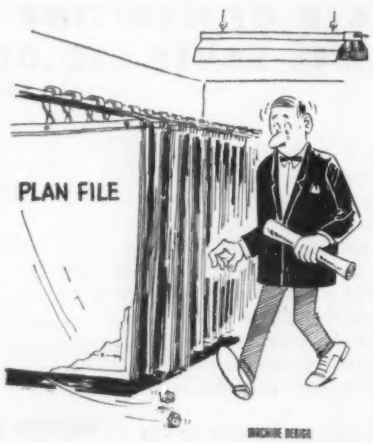
Instrument Society of America. Instrument-Automation Conference and Exhibit and 15th Annual Meeting to be held in the Coliseum, New York. Additional information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 27-30—

Association of Iron and Steel Engineers. Exposition and Convention to be held at the Auditorium, Cleveland. Further information is available from AISE headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Oct. 9-14—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago. Additional information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.



Oct. 10-11—

Sixth Conference on Mechanisms to be held at Purdue University, Lafayette, Ind. Conference is sponsored by Purdue and MACHINE DESIGN. Further information is available from Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Short Courses and Symposia

Aug. 1-19—

1960 Statistical Methods in Industry Program, including courses in quality control by statistical methods and in industrial reliability, to be held at the University of California. Fifteen-day courses in design and analysis of industrial experiments and in basic measurements and standards (including nondestructive testing) will also be offered. Additional information can be obtained from Prof. Edward Coleman, Department of Engineering, University of California, Los Angeles 24, Calif.

Aug. 15-19; 22-26, 29-Sept. 2—

Photoelasticity and Strain Gages—three one-week courses on experimental stress analysis for missiles and space craft to be held at UCLA. Included will be theory, as well as discussions and demonstrations of latest techniques, especially with respect to applications at high and low temperatures. The first week's course, on industrial photoelasticity, consists of lectures and laboratory work; the second week is a lecture course on strain gages; and the third week is a laboratory course on strain gages. Further data is available from Engineering Extension, Engineering Bldg. Unit II, Room 6266, University of California, Los Angeles 24, Calif.

Aug. 22-26—

Thermonuclear Plasma Physics Symposium, to be held in Gatlinburg, Tenn., will deal with elementary aspects of achieving controllable release of energy in significant amounts from thermonuclear fusion reactions. Sponsors are Oak Ridge National Laboratory

An assignment in migrating ions . . . for Lukens Application Research.

Corrosion. This is the metallurgical result of ion migration. It's a frequent opponent for the Lukens Application Engineer in his job of helping you determine the *best* steel for "problem" applications. In the case of miscellaneous-cargo tankers, for instance, corrosive hot caustics are often carried on one leg of a trip; on another... high purity glycerine that must not become contaminated. How, marine designers asked, can we get *economical* protection both for cargoes and hold tanks? Drawing on years of experience with process industries equipment, Lukens Application Research suggested the answer: nickel-clad steel—highly corrosion-resistant, comparatively inexpensive—with a special sodium hydride finish that is easy to clean, expedites conversion.

Experience and ingenuity are the stock-in-trade of Lukens Application Engineers. For personal assistance on problems of metals application—corrosion, cryogenics, metal expansivity, abrasion, structural stress—please contact us. Write Manager, Application Engineering, E70 Services Building, Lukens Steel Company, Coatesville, Pennsylvania. Also contact us for Clad Steel Equipment Bulletin No. E70.

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ACTUAL X-RAY PHOTO* OF TRI-CLAD '55' 7½ HP MOTOR

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ALLOWS MAXIMUM MOTOR OUTPUT— SAFELY!

Now—Tri-Clad '55' motors have simple, direct-acting thermal protectors that positively prevent overload failures!

New Thermo-Tector heat-sensing switches buried in motor windings react *instantly* to prevent heat damage. Unique Thermo-Tector "anticipation" feature varies motor shutoff point according to rate of winding heat rise. This ends need for operating safety margin, allows you to get *full output* from Tri-Clad '55' motors.

Thermo-Tector system requires *no costly amplifying relays*—works with any conventional G-E motor controller. Thermo-Tector protection is available on *all* Tri-Clad '55' motors in frames 254U-445U.

For more information, contact your General Electric Apparatus Sales Office or write for Bulletin GEA-7092, Section 866-01, Schenectady 5, New York.

*Photo made from radiograph taken with 1,000,000-volt G-E Resotron® X-ray machine at General Electric's Large Steam Turbine-Generator Department.

†Trade-mark of General Electric Company.

SMALL AC MOTOR & GENERATOR DEPT.

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SCHENECTADY 5, NEW YORK

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(operated by Union Carbide Corp.) and the Oak Ridge Institute of Nuclear Studies, in co-operation with the U. S. Atomic Energy Commission. Further information can be obtained from the laboratory, P. O. Box X, Oak Ridge, Tenn.

Sept. 12-16—

Course on Technical Report Writing for Engineers and Scientists to be held at the University of California, Los Angeles. Additional information is available from Engineering Extension, Room 6266, Engineering Bldg., Unit II, University of California, Los Angeles 24, Calif.

Sept. 14-15—

Joint Military-Industrial Electronic Test Equipment Symposium to be held at Armour Research Foundation under the sponsorship of the Office of the Director of Defense Research and Engineering and the Department of the Army Signal Corp. New concepts in measurement, latest instrumentation design techniques, and advanced data processing methods will be covered. Additional information can be obtained from Robert Brausch, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

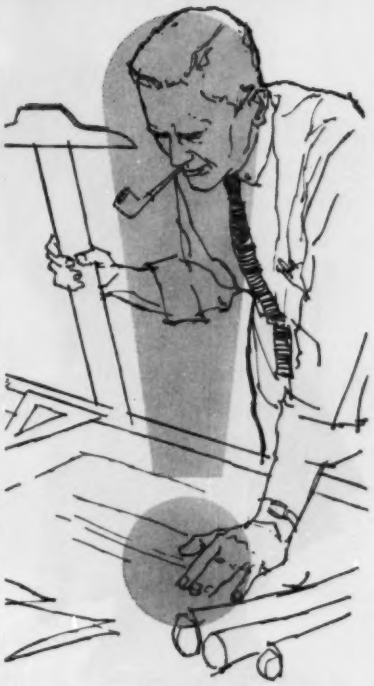
Sept. 19-30—

Technical Report Writing for Engineers and Scientists Seminar to be held at Pennsylvania State University. Lecture, discussion, and workshop sessions will cover all phases of technical report preparation. Further information is available from Conference Center, The Pennsylvania State University, University Park, Pa.

Oct. 4-7—

Eighth Annual Human Engineering Institute to be conducted by Dunlap & Associates, Stamford, Conn. Program will include three days of technical sessions, a half-day on management and contractual aspects of human engineering efforts, and opportunity for private conferences. Further information can be obtained from Dunlap & Associates, 429 Atlantic St., Stamford, Conn.

ASK FOR HELP



...it costs you nothing

Concerned over an important deadline that's closing in fast? Too pressed with a heavy workload to complete all priority assignments? Not looking forward to writing that next progress report?

A-P-C stainless steel engineers and craftsmen are famous for their "rescue operations." No one knows stainless steel fabrication better... no other manufacturer can boast of higher quality or faster service.

Extremely complex shapes and forms are routine assignments for these stainless steel specialists. Unbelievably deep draws; smooth, virtually invisible weldments; large or small production runs.

Whether you're shooting a rocket to the moon or building a better mousetrap, A-P-C engineers can help you with the design and fabrication of stainless steel components. **ASK FOR HELP. Write or call the**

Craftsmen in Stainless Steel

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ALLOY PRODUCTS CORP.

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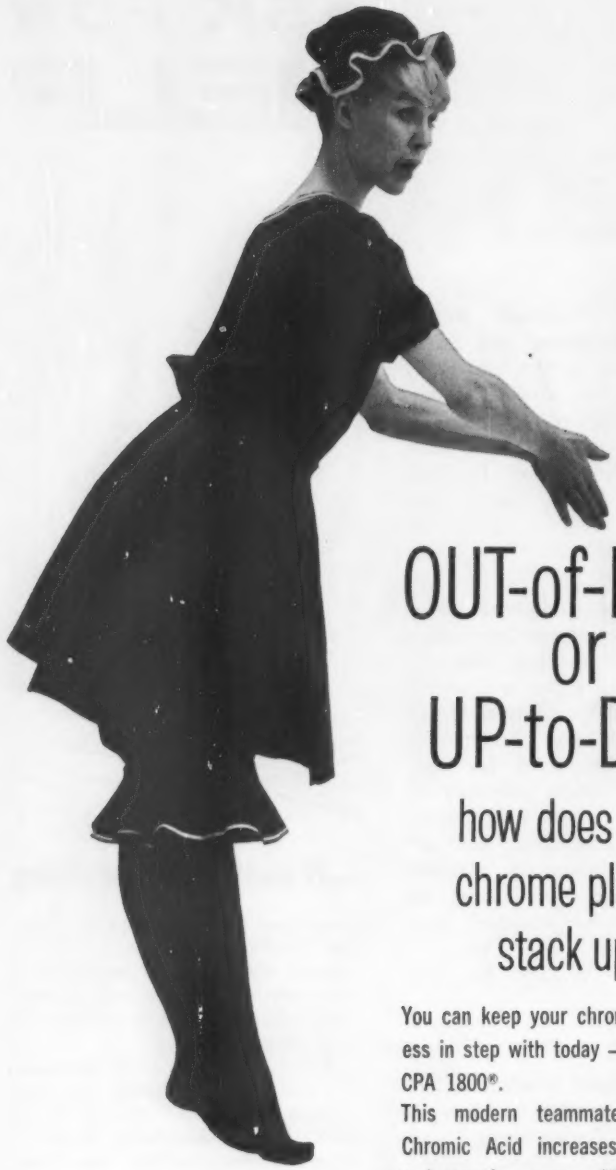


OUT-of-DATE or UP-to-DATE

how does your chrome plating stack up?

You can keep your chrome-plating process in step with today — with Diamond CPA 1800®.

This modern teammate for Diamond Chromic Acid increases plating speed and covering power. Allows a broader operating range. Simplifies anoding and produces a brighter, harder coating. Improves the metallurgical characteristics of chromium plate.

In short: Diamond CPA 1800 cuts your unit costs and saves you money. Diamond developed it. Your Diamond CPA 1800 Distributor can supply it where and when you need it.

For further information — call or write Diamond Alkali Company, 300 Union Commerce Building, Cleveland 14, Ohio.

Diamond Chemicals

Circle 428 on Page 19

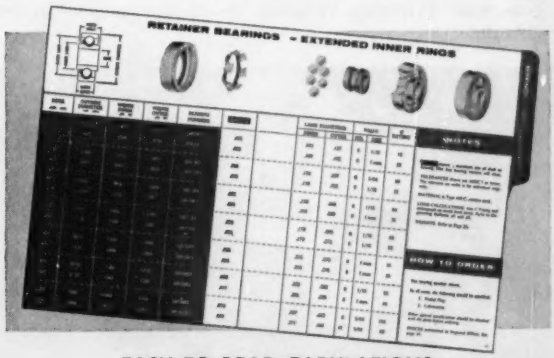
"...NEW MANUAL EXPANDS INFORMATION ON MINIATURE & INSTRUMENT BALL BEARINGS..."

By **GEORGE HAMPSON**, *Vice President-Sales, New Hampshire Ball Bearings, Inc.*

"... this 'Design & Purchasing Manual' replaces the first-of-its-kind 'Technical Data and Catalog' book NEW HAMPSHIRE published in 1957. As the 'Technical Data' (black cover) was then, we believe the 'Manual' (green cover) is now, the most complete source of information on miniature and instrument ball bearings in print. About 50 pages larger than the old book, the 'Manual' was expanded that much to include information developed since 1957 on ordering, maintaining, fitting, lubricating and testing miniature bearings."

QUALITY — AND ASSURANCE

"The significance of ABEC Class 7 tolerances to running quality of instrument bearings is covered in one section with a brief, to-the-point explanation of how improved bearing geometry helps the design and quality control engineer. A pictures-and-words story describes NEW HAMPSHIRE's Quality Assurance by which this high standard for miniature bearings is maintained in production. The equipment used, and how used, is fully described. Testing geometry and finish, cleaning and lubricating, functional testing of bearings, and metal research are some of the subjects covered."



EASY-TO-READ TABULATIONS

"An even easier-to-read tabulation form is used to list NEW HAMPSHIRE Bearings in Bore/OD/Width sequence for quick identification and selection when ordering or writing specifications. Three hundred seventy bearings are so listed, including NEW HAMPSHIRE wafers, the narrowest shielded retainer bearings possible for given Bore/OD combinations, and developed especially for manufacturers of synchros, servos, small motors, potentiometers, miniature gear trains, and other products where space-for-bearings is a problem."

BEARING NUMBERS EXPLAINED

"The 'Design & Purchasing Manual' includes a section on Designation, Packaging and Marking in which NEW HAMPSHIRE Bearing number symbols are explained, methods of packaging available from NEW HAMPSHIRE are described, and materials identification codes listed. Study of this section can work savings of money and time by minimizing the necessity of returning mistake-ordered bearings. In addition, simple HOW TO ORDER instructions are included on every page of bearing tabulations.
A Table of Weights is provided to assist those responsible for systems design and planning to compute weights of the NEW HAMPSHIRE Bearings specified and included."

ENGINEERING BULLETINS EXPANDED

"The Engineering Bulletins have been expanded and brought up-to-date to inform designers, engineers and quality control personnel of the latest developments related to Lubrication, Load Ratings, Fits, Speed, and other factors affecting performance and life of instrument bearings. There are now 22 Bulletins on as many subjects, including the two most recently developed, Duplex Bearings, and Bearing Roundness —one hundred seventeen pages of technical information on miniature and instrument ball bearings compiled and written by Bearing Engineers."

REGISTERED COPIES AVAILABLE

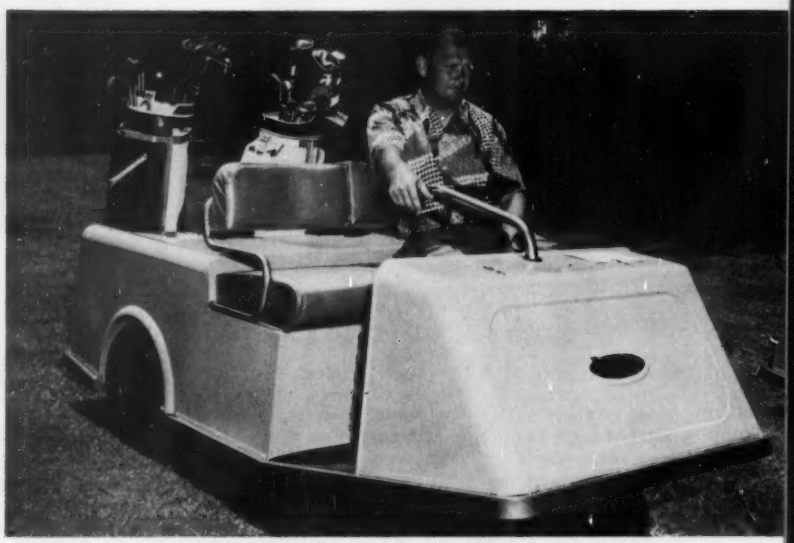
"The 'Design & Purchasing Manual' should be in the library of every designer, draftsman and buyer specifying or purchasing miniature and instrument ball bearings. Each copy is registered to its recipient. Your name and title sent to us on your company letterhead will bring your copy to you by return mail."

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

Circle 429 on Page 19

Toughest in its Onan CCK

Built for rugged performance



POWERFUL AND QUIET! This Onan-driven golf cart takes two, even three players anywhere on the course. Idles down to a whisper while they're shooting. Smooth control. And remarkably economical with its 1000 rpm governor. Put this versatile 2-cylinder engine in *your* new product planning.

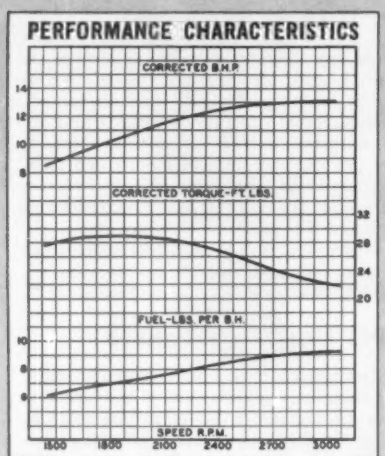
100-MILE-AN-HOUR AIR BLAST! In this high velocity sprayer for pest and sanitation control, Onan CCK engine revs up a storm—with no time out. CCK will deliver up to 13 hp during *sustained* operation at over 3000 rpm. Here's performance and dependability ready to go to work in *your* equipment.

Check these specs against your requirements

Where you need smooth, vibrationless operation . . . light weight . . . space-saving compactness . . . fuel-saving economy . . . and rugged, long-life performance . . . you'll find your answers in Onan's CCK. Note a few of CCK's many applications on these pages. Besides the welder shown, five different makes of portable welders use CCK. Also, leading manufacturers of engine-driven truck refrigeration systems standardize on CCK.

A FEW OF CCK's FEATURES—

- Stellite-faced exhaust valves
- Solid Stellite exhaust inserts
- Rotating exhaust valves
- Full pressure lubrication
- Jumbo oil bath air cleaner
- Oil pressure indicator
- Magneto ignition
- Governor regulation: 5%
- Extra large bearing surfaces
- Axial-flow pressure cooling
- 3-quart oil sump
- Rugged Alloy C. I. construction
- Short extra-heavy crankshaft



Performance Tests conducted with all accessories installed, S.A.E. Test Code and data corrected to S.A.E. standard. Engine as shipped will produce at least 85% of corrected bhp. After run-in, power will increase to at least 95% of corrected bhp.

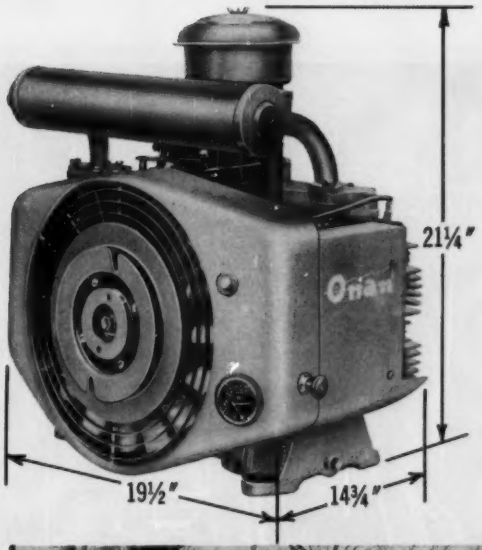
CALL Bob Westrum at Onan for complete information. He's an expert in solving tough power problems for Original Equipment Manufacturers. Minneapolis, FEderal 2-1155.

OR write for fact file on CCK including complete line of accessories and other Onan O.E.M. products—including engine-driven electric power plants to 230 KW... separate generators... engine compressors.

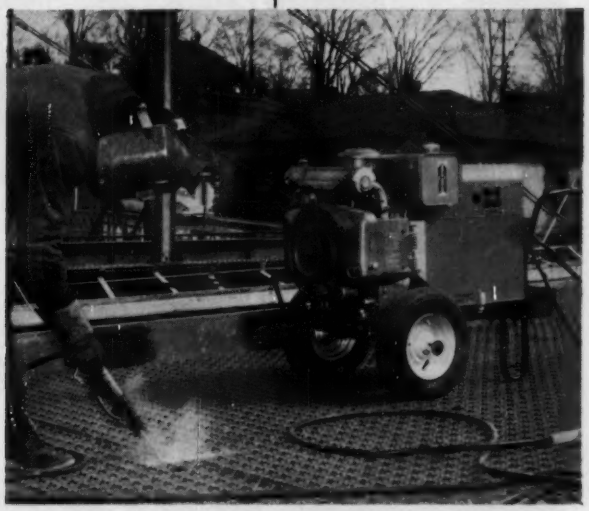
Class! Engine

12.9 hp at 2700 rpm. Alternate-firing, 4-cycle, 2-cylinder, opposed, air-cooled, horizontal design. Gasoline or gas operation.

. . . weighs only 148 lbs.

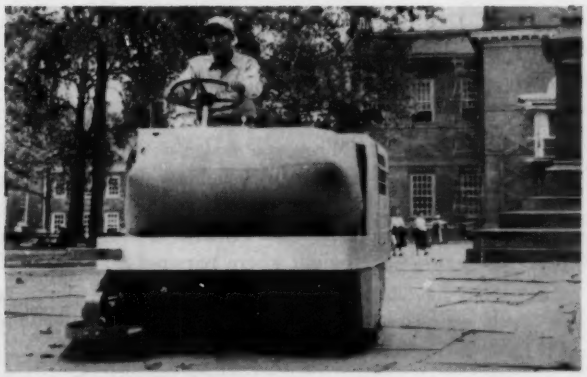


UP AND AT 'EM WITH 45 FT. REACH! In this hydraulically-operated aerial ladder truck . . . where steady, controlled power drive is vital . . . CCK demonstrates true championship ability. Where can *you* use this outstanding 2-cylinder engine? Let Onan help.



WEIGHT-SAVING CCK means easy *portability* in this high-output welder. Goes anywhere. Handles toughest jobs. CCK delivers plenty of reserve power when needed.

IT SWEEPS! VACUUMS! DUMPS! This compact, nimble CCK-driven sweeper solves municipal and other clean-up problems in a hurry. Need maneuverability and compactness in your equipment? Put CCK to work!



Onan

WORLD'S LEADING BUILDER OF ENGINE-DRIVEN ELECTRIC POWER PLANTS

D. W. Onan & Sons Inc.,
2914 University Ave. S. E.,
Minneapolis 14, Minn.

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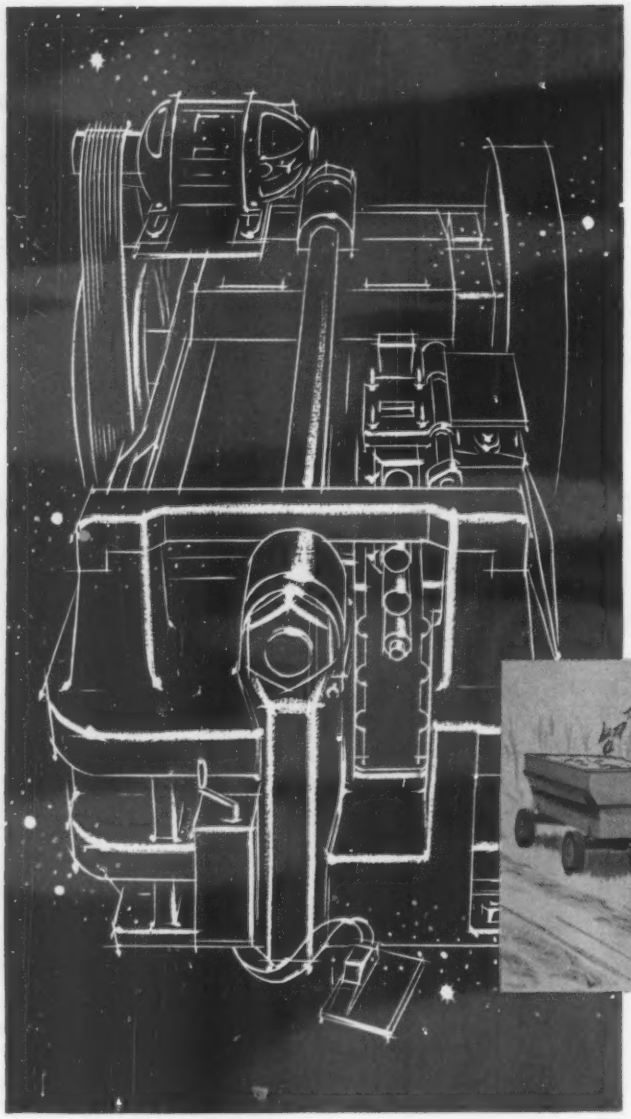
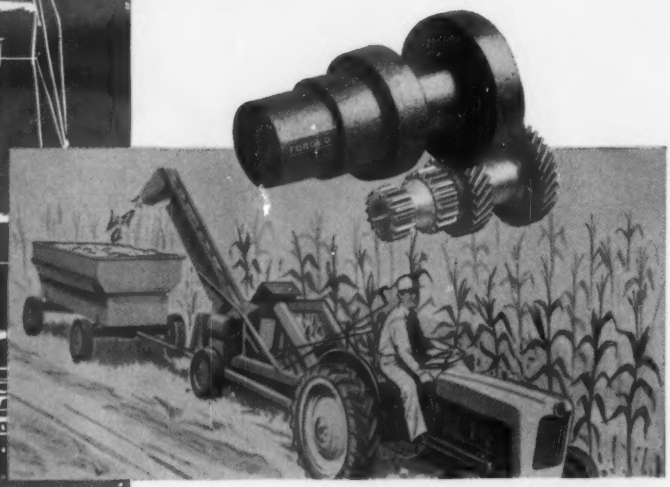


Upsetter, or horizontal forging machine

RESISTANCE TO PUNISHMENT of any severe-service part increased by designing it to be forged



Gear blanks for tractor and farm implement transmissions are designed to be upset-forged, usually with integral forged stub shafts. Forging gives these vital parts maximum resistance to gear-clashing shifts. Transmission life can be equal to equipment life when gears are FORGED.

When you *design with forgings* right from the start, you take full advantage of the many benefits which only forgings offer: highest ratio of strength to weight . . . highest resistance to impact, shock, vibration, torsion . . . preferential orientation of flow lines in the forging to concentrate strength where required . . . absence of wasteful inclusions and voids.

Forged parts start out as *better* metal . . . are made *even better* by the hammer blows or pressures of the forging process. Write for literature to help you design, specify, and procure forged parts.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

No difference between hex and cap screws

It's not the *name* of a standard fastener that determines whether to use it for a particular application, but vice versa. The *application* requirements for strength and tolerances dictate the fastener.

Thus, if you have a joint that calls for certain tolerances in a screw, obviously the one which satisfies those tolerances is the right fastener.

IDENTICAL STANDARDS

In the case of cap screws and hex screws, the standards will show you that these are merely different names for the same product. They're actually made on the same machines, to identical tolerances, and from identical materials.

No reason then to differentiate. For tapped holes, merely specify Hex Screws (SAE Grade 2) or High Strength Hex Screws (SAE Grade 5), and you'll get the *right* fastener with the quality needed.

For bolted joints, these same items are supplied with nuts when specified.

This should suggest a way you can extend standardization in your plant . . . and benefit from our new simplification of nomenclature which calls *any* fastener with head on one end and threads on the other a *screw;* and a screw plus nut a *bolt.*

See how "holding power" can cut fastener costs

SIZE	SAE GRADE	SAE PROOF LOAD	COST RATIO
¾"	Gr. 5	28,400 lbs.	100%
1"	Gr. 2	16,950 lbs.	188%
1⅛"	Gr. 2	21,350 lbs.	239%
1¼"	Gr. 2	27,100 lbs.	277%

Since the usual job of a threaded fastener is to hold an assembly tightly together, its *clamping force* is what you're really utilizing. This seems obvious. But how best to get the clamping force needed for the joint design? Not so obvious. Looking at size alone can be misleading . . . *and quite costly,* as the chart above demonstrates.

HOLDING POWER MEANS MORE THAN SIZE

SAE "proof load" of four different hex screws of standard steels, along with typical cost ratios, are compared. Almost unbelievable, isn't it? Yet it's a fact that the smallest of the group—the heat treated SAE Grade 5 *RB&W High Strength Hex Screw* exceeds all the others in load capacity. It can be used in place of any of the others in most normal usages.

Since it's smallest and therefore weighs the least, it also costs less... 64% less than the 1¼-inch grade 2 hex screw; 58% less than the 1⅛-inch; 46% less than the 1-inch. And since holes can be made smaller, there are also the savings in production drilling . . . and possibly in materials, too.

DESIGN ADVANTAGE

Remember, too, that smaller fasteners are more easily torqued to higher preload levels . . . which helps keep joints tight, makes them more vibration-proof.

If you would like to explore this approach to fastener economy and better utilization of "holding power," consult with an RB&W specialist. Let him contribute his fastener knowledge to your design and production needs. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

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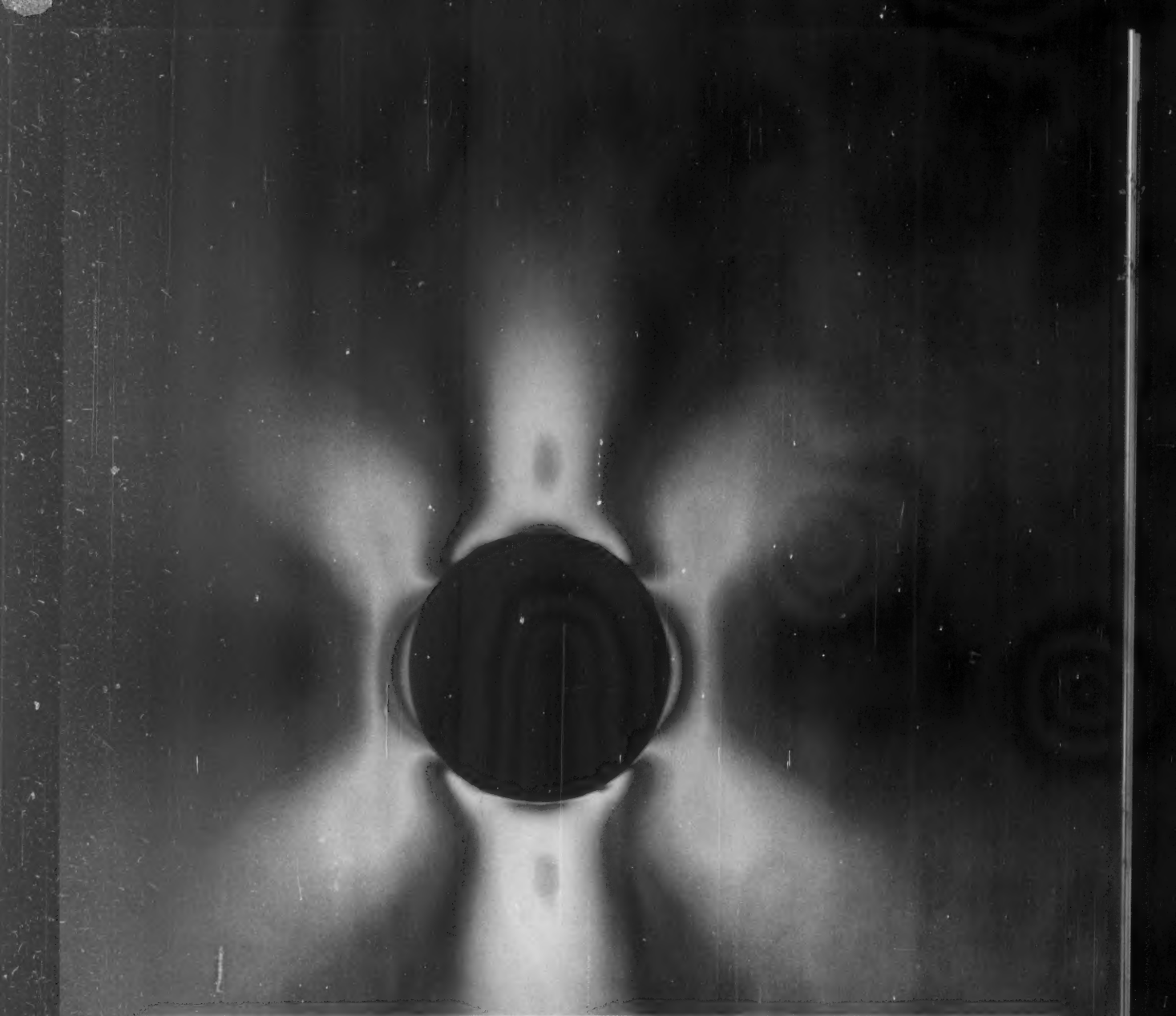


Photo-elastic stress patterns produced by models photographed with polarized light are one of the modern analytic tools available for ever-increasing perfection of Malleable iron castings.

For Greatest Strength Per Dollar...Use Malleable

To improve quality and cut costs, you'll find nothing better than Malleable iron castings. They provide more strength per dollar than any other metal, ferrous or non-ferrous! With Malleable you also get proven toughness, uniform quality and unsurpassed machinability.

See for yourself how much Malleable castings will improve your products and cut your costs. Send drawings or an outline of your requirements to a nearby Malleable castings producer who displays this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

For detailed information on "Strength Characteristics of Malleable Iron Castings", contact any of the progressive companies listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

"Value Analysis" Proves–

Malleable Castings Improve Quality, Reduce Costs

When "Value Analysis" is your task, consider these outstanding advantages of Malleable iron castings: more strength per dollar than any other metal, ferrous or non-ferrous; exceptional machinability; metal exactly and only where it is needed; job-proven toughness.

Wide Range of Desirable Properties Available in Malleable

Standard and pearlitic Malleable irons are available with strengths ranging from 50,000 p.s.i. to 120,000 p.s.i. tensile.

Note in this table the high ratio of yield strengths to tensile strengths — especially important to you because yield strength is generally the measure of useable strength.

TENSILE PROPERTIES—A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Yield as a Percent of Tensile
Standard			
35018	53,000	35,000	66
32510	50,000	32,500	65
Pearlitic			
45010	65,000	45,000	69
45007	68,000	45,000	66
48004	70,000	48,000	69
50007	75,000	50,000	67
53004	80,000	53,000	66
60003	80,000	60,000	75
80002	100,000	80,000	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

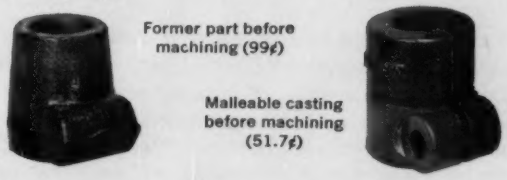
Other Mechanical Properties

	Standard	Pearlitic
Modulus of Elasticity in Tension, p.s.i.	25,000,000	26,000,000 — 28,000,000
Ratio of Fatigue Strength to Tensile Strength	0.54	0.40 — 0.50
Shear Strength — % of Tensile Strength	80 — 90%	70 — 85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000

Switch to Malleable Saves 47% on Railroad Car Thrust Collar

One of countless examples of cost reduction obtained by changing from other materials or processes to Malleable castings is this thrust collar used on railroad maintenance cars. While the steel part formerly used performed satisfactorily, it cost 99¢ before machining.

The cost of the standard Malleable casting before machining is only 51.7¢ — a saving of 47.3¢! Added to this, four machining operations — drilling of bolt hole, spot facing for bolt head and nut, milling the sleeve slot and sawing the transverse slot — were eliminated by switching to a casting. All remaining machining operations are improved due to Malleable's exceptional machinability.



Former part before machining (99¢)

Malleable casting before machining (51.7¢)

Cost-Saving Engineering Assistance Available

The kind of engineering assistance that cut costs and improved product quality for these companies and thousands of others is available to you from any of the progressive producers of Malleable castings that are members of the Malleable Castings Council. Start increasing your product profitability right now — contact any of the companies listed below.

Free Information Folder

Your copy of an informative folder, *Data Unit 110—Malleable Castings in the Value Analysis Spotlight*, is available free from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, or from any member company.

For Quality and Economy...Use MALLEABLE

For Service In Your Area Contact...

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

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DESIGN FACTS ABOUT ABRASION RESISTANCE

New data on gouging abrasion show 12-2 alloy offers up to 50% longer service

• **Some vital new facts about abrasive wear** — and wear resistance — have been developed by Climax Molybdenum. Most of the data are based on Climax's experience in mining molybdenite where abrasion annually results in the loss of many tons of alloys. This information should help save hours of costly engineering time.

• **Part of the data concern gouging abrasion.** Gouging occurs when coarse materials cut into a part's wearing surface with sufficient force to tear off large segments. It can occur under low velocity or at high velocity and is usually accompanied by severe impacts. In mining applications, *gouging commonly causes wear at the rate of 1 to 5" per 100 hours of operation,* depending on the ore.

• **Many designers specify** a new, high-carbon austenitic steel — 12-2 Alloy:

COMPOSITION: 1.10/1.40% C; 12.00/14.00% Mn; 0.40/1.00% Si; 0.05% S max; 0.06% P max; 1.90/2.10% Mo.

This material is heat treated to produce a structure containing fine, well dispersed spheroidized carbides. The 12-2 Alloy is tougher and provides better abrasion resistance and higher yield strength than standard austenitic manganese steel. Here's how the two compare:

	Standard Manganese Steel		12-2 Alloy
	1900 F WQ	1100 F + 1800 F WQ	1100 F + 1800 F WQ
Yield strength, psi	55,000	55,000	70,000
Tensile strength, psi	115,000	113,000	130,000
Brinell hardness	175	175	215
Elongation, % in 2 in.	40	35	30
Reduction of area, %	30	35	30
Tangent modulus	1.3	1.5	2.5

• **Parts made of 12-2 Alloy are already proving themselves** under the severest abrasion. In fact, crusher liners, grizzly screens, slusher-scraper parts, and hammers in impact pulverizers made of 12-2 continually outlast parts made of conventional manganese steels — by as much as 50% — thereby slashing replacement costs and saving hours of costly downtime.

• **More information is available on all aspects of abrasion and abrasion-resistant metals from Climax. For your copy of our 36-page booklet "The Role of Molybdenum in Abrasion-Resistant Materials" — and other data — write:**

Three cases where parts made of 12-2 really paid off

1. Folding-type scrapers, like the one shown above, get continual abuse from gouging abrasion and impacts. Wear rates normally range from 1 to 5" per 100 hours of operation! Blades made of 12-2 Alloy have lasted about 30% longer than blades made of regular austenitic manganese steels.

2. In the crushing plant, minus 8" ore falling from a conveyor belt continually battered and gouged a grizzly screen's 1¼ x 4" sections. Climax found sections made of 12-2 Alloy lasted 18% longer.

3. For four years, Climax alternated cone-crusher liners made of 12-2 Alloy dispersion hardened with liners made of austenitic manganese steels. The results? The average life of the 12-2 liners was about 50% greater than that of the competitive material.

CLIMAX MOLYBDENUM

CLIMAX MOLYBDENUM COMPANY

A division of American Metal Climax, Inc. / 1270 Avenue of the Americas, New York 20, N.Y.

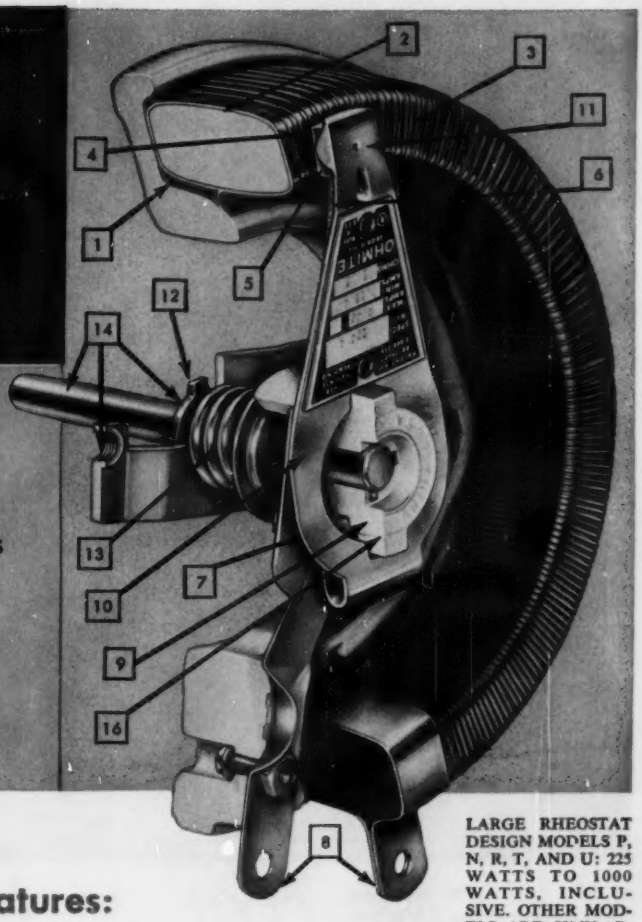
Circle 434 on Page 19

OHMITE

RHEOSTATS

NOW 11 Sizes! 12½ to 1000 Watts

Ohmite offers you industry's most complete line of rheostats. All sizes are available from stock in a wide range of resistance values, including the NEW Model "E." Ten sizes are available to meet MIL-R-22A requirements in *each* of the 26 type designations.



LARGE RHEOSTAT DESIGN MODELS P, N, R, T, AND U: 225 WATTS TO 1000 WATTS, INCLUSIVE. OTHER MODELS ARE SIMILAR.

16 Quality Engineering Features:

1. Vitreous enamel bonds the core and base together into one integral unit.
2. The wire is wound over a solid porcelain core, and each turn is locked against shifting by vitreous enamel. Uniform or tapered winding.
3. Close graduation of control. Each turn of wire is a separate resistance step.
4. Large, flat surface upon which the contact brush rides.
5. Metal-graphite contact brush (varied to fit current and resistance) insures good contact, with negligible wear on the resistance wire.
6. Shunt pigtail of ample size carries the current directly to the slip-ring.
7. Large slip-ring of high-current carrying ability minimizes mechanical wear and provides connection from the moving contact to the terminal.
8. Potentiometer use. The rheostats are provided with three terminals so they can be used as potentiometers or voltage dividers.
9. High strength ceramic hub insulates the shaft and bushings from all live parts. All sizes will stand a 3000 volt a-c breakdown test to ground.
10. The contact arm is a long tempered steel spring which assures uniform contact pressure at all times. Cadmium-plated for corrosion resistance.
11. Rounded pivot holds contact brush in flush-floating contact with wire.
12. Stops which are keyed to the shaft and base limit the rotation—thus no torsional strain is imposed on the contact arm on stopping.
13. Compression spring maintains uniform pressure and electrical contact between slip-ring and center lead at all times.
14. Models E, H, J, G, K, and L: End-thrust is taken by a retaining ring. Models P, N, R, T, and U: End-thrust is taken by a stop washer. Steel shaft in brass bushing provides a wear-resistant, wobble-free bearing.
15. Ohmite rheostats meet requirements of NEMA and EIA (formerly RETMA).
16. There are only ceramic and metal in the construction of Ohmite rheostats—there is nothing to char, burn, shrink, or deteriorate.

Write on company letterhead for Catalog 58.

OHMITE MANUFACTURING COMPANY
3616 HOWARD STREET
SKOKIE, ILLINOIS

RHEOSTATS • RESISTORS • TAP SWITCHES
RELAYS • R.F. CHOKES • TANTALUM CAPACITORS
VARIABLE TRANSFORMERS • GERMANIUM DIODES

Circle 435 on Page 19

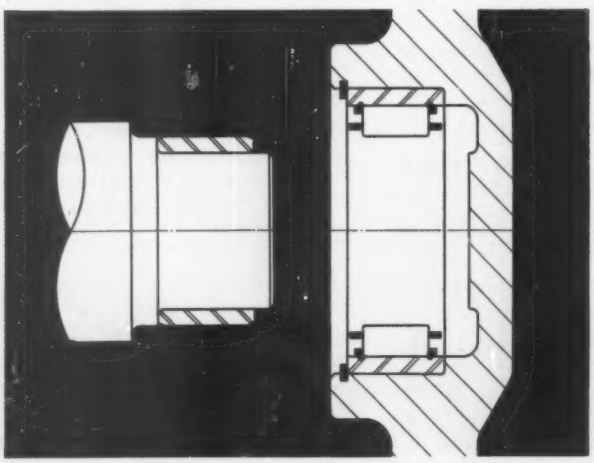
ALL THESE SOLVED WHEN

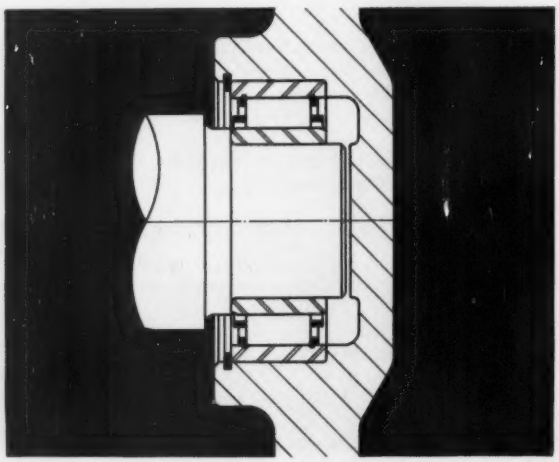
SAVE COST

Again, how simple this shaft becomes when you use Hyatt Hy-Roll bearings. It's easy to design, quickly drawn and requires no costly end clamps, threads, nuts, screws or washers. That's because Hyatt Hy-Roll bearings can be pressed on the shaft . . . to become, for your purposes, virtually a part of the shaft. Since Hyatt Hy-Roll races are made from case-hardened, carburizing type steel, rather than through-hardened, they permit much heavier press fits without danger of cracking.

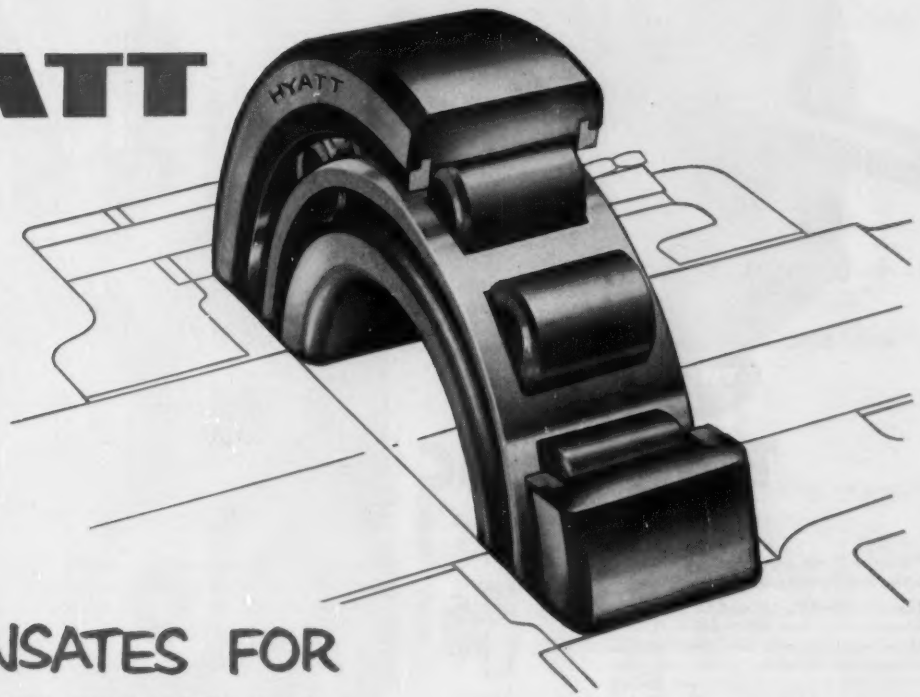
SAVE TIME

When equipment is being assembled you can see why Hyatt makes all separable races interchangeable within the same part number. It allows you to press an inner race on the shaft at one work station, then later fit it into any of the mating assemblies already installed in the housing. You don't have to worry about matched assemblies because with Hyatt Hy-Rolls selective fits are unnecessary. Think of the time it saves!





PROBLEMS ARE EASILY YOUR "SPECS" READ HYATT

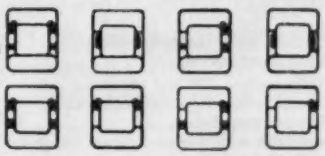


COMPENSATES FOR SHAFT EXPANSION

Heat can be a critical factor in the choice of a radial bearing. When the temperature rise causes lateral shaft expansion, it's safer to avoid laterally locked bearings. Used on a long shaft, they become misaligned, cramped, and overloaded when the shaft begins to heat up and expands laterally.

It's a problem you can avoid, very simply, with Hyatt Cylindrical Roller Bearings. In Hyatt's design, an extra length, separable inner race allows the shaft to float horizontally. This bearing compensates for lateral expansion, automatically, without changing the bearing centers and without depending upon uncertain float of a bearing loosely fitted in a housing. The usual practice is to hold one end of the shaft or roll while you allow "free lateral" at the other end by using a Hyatt Hy-Roll Bearing with a separable inner race.

Hyatt produces 10 major bearing types—four have separable inner races



—four non-separable

—and two have separable outer races.

The separable race can be omitted and rollers operated directly on the shaft or in the housing bore, in instances where the bearing surfaces can be brought to suitable hardness and finish.

For full details on selection and application of these bearings see Hyatt Catalog 150 or call your nearest Hyatt sales engineer.

Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey

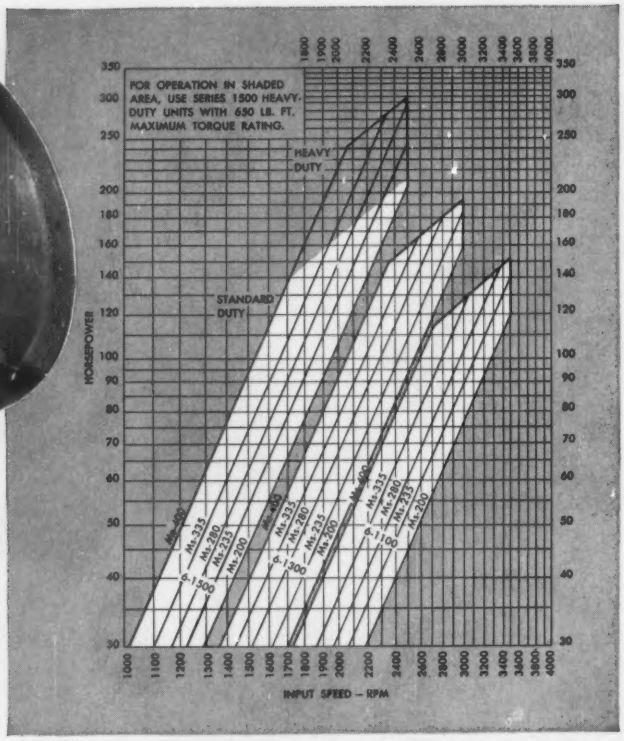
HYATT HY-ROLL BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM RELIABILITY

Circle 436 on Page 19

TWIN DISC

Torque Converters


FOR OPERATION IN SHADED AREA, USE SERIES 1500 HEAVY-DUTY UNITS WITH 650 LB. FT. MAXIMUM TORQUE RATING.
HEAVY DUTY
STANDARD DUTY
HORSEPOWER
INPUT SPEED – RPM

This chart gives horsepower and speed ratings for all Twin Disc Single-Stage Converters. Note that the 1500 Series is furnished in standard and heavy duty capacities. The figure "6" preceding the series number refers to the type of circuit.

"Stripped" or cartridge-type units for OEM in-line design

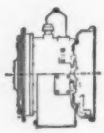
Nine models—11", 13" and 15" sizes.
Torque ratings from 235 to 650 lb.-ft.
Three types: Converter only; converter with oil-actuated disconnect clutch; and converter with disconnect clutch and lock-up direct drive clutch.

Basic power take-off units

Three models—13" and 15" sizes.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.

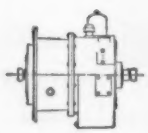
Spacer units for connection to transmissions

Three models—13" and 15" sizes.
Torque ratings from 350 to 650 lb.-ft.
Flanged output shaft.
Available with dummy flywheel for automotive type clutches.



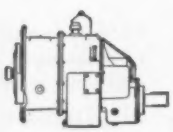
Units equipped with front-end disconnect clutch

Four models—13" and 15" sizes.
Single or double plate clutch.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.
Optional: Boom lowering freewheel for shovels and cranes.



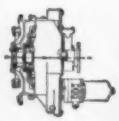
Units equipped with disconnect clutch plus 2:1 ratio reduction gear

Three models—13" and 15" sizes.
Single or double plate 11" clutch.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.
Optional: Boom lowering freewheel.



Sumpless PTO units for power-shift transmissions

Three models—13" and 15" sizes.
Live power take-off for auxiliary drives.
Torque ratings from 350 to 650 lb.-ft.
Flanged output shaft.
Optional: Rubber block input drive.



SINGLE-STAGE TORQUE CONVERTERS

25 models

Virtually any single-stage torque converter requirement can be met with one of Twin Disc's standard rotating-housing units. The scope of the Twin Disc line can be seen from the summarized listing at left.

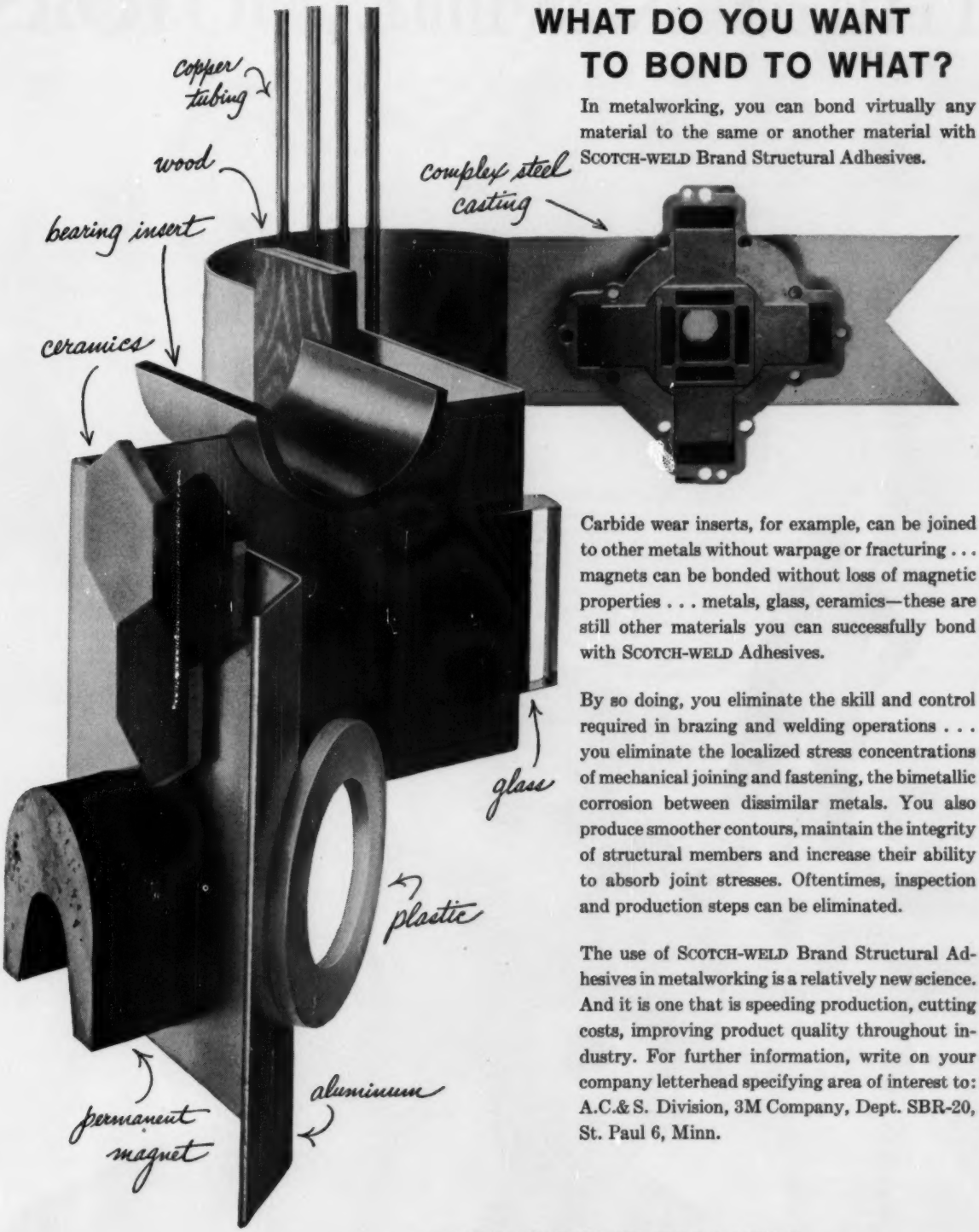
Each converter size—11", 13" and 15"—has five interchangeable impellers which vary with respect to blade number and pitch so that each has a different torque absorption capacity. This exclusive Twin Disc design feature provides a 2:1 horsepower spread for each converter series. It insures correct matching of converter to engine and also permits a subsequent increase in engine horsepower without dimensional changes in the torque converter.

Twin Disc Single-Stage Converters are available as "industrial" (self-contained) units or as "stripped" (cartridge type) units for incorporation into OEM transmission designs. Complete details are contained in Bulletin 510. For your copy, write TWIN DISC CLUTCH COMPANY, Hydraulic Division, Rockford, Illinois.

Circle 437 on Page 19

WHAT DO YOU WANT TO BOND TO WHAT?

In metalworking, you can bond virtually any material to the same or another material with SCOTCH-WELD Brand Structural Adhesives.



Carbide wear inserts, for example, can be joined to other metals without warpage or fracturing . . . magnets can be bonded without loss of magnetic properties . . . metals, glass, ceramics—these are still other materials you can successfully bond with SCOTCH-WELD Adhesives.

By so doing, you eliminate the skill and control required in brazing and welding operations . . . you eliminate the localized stress concentrations of mechanical joining and fastening, the bimetallic corrosion between dissimilar metals. You also produce smoother contours, maintain the integrity of structural members and increase their ability to absorb joint stresses. Oftentimes, inspection and production steps can be eliminated.

The use of SCOTCH-WELD Brand Structural Adhesives in metalworking is a relatively new science. And it is one that is speeding production, cutting costs, improving product quality throughout industry. For further information, write on your company letterhead specifying area of interest to: A.C.&S. Division, 3M Company, Dept. SBR-20, St. Paul 6, Minn.

ADHESIVES, COATINGS AND SEALERS DIVISION

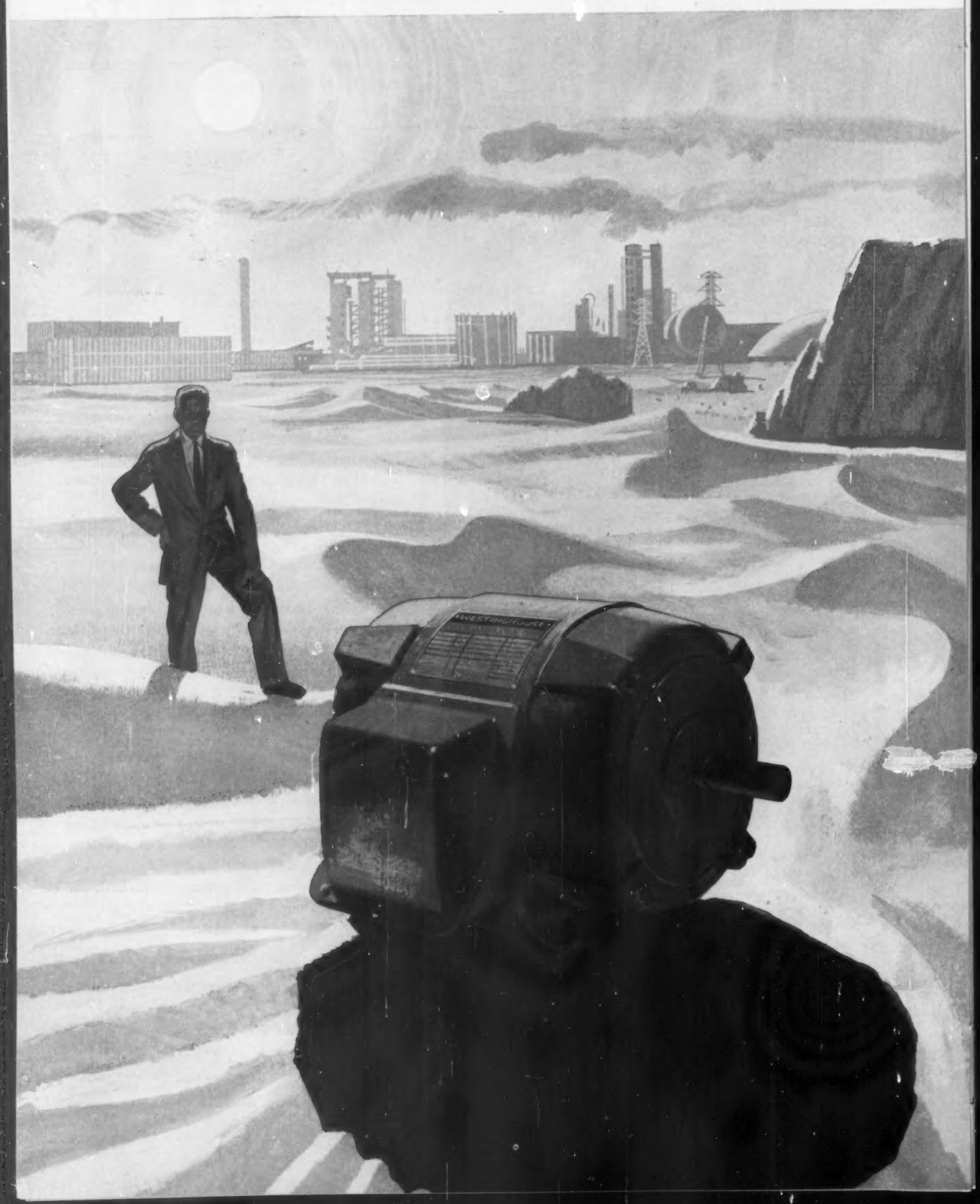
MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

New Guardistor

THE MAN & THE MOTORS



FROM WESTINGHOUSE

Guardistor motors let you match the full capability of the motor to the job— with complete safety—absolute confidence

Our Marketing Manager says:

- "You can match the motor to the load . . . use all the motor you are paying for.
- Provides positive protection based on winding temperature . . . *not* load current and/or power supply fluctuations.
- Eliminates time and expense of changing winter-summer heaters. No nuisance tripping, it's fail-safe . . ."

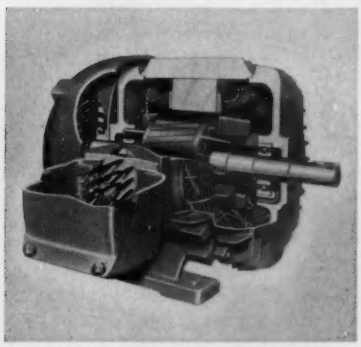
Our Engineering Manager says:

"With the breakthrough development of the Westinghouse Positive Temperature Coefficient thermistors, for the first time we can provide inherent protection against motor failure caused by excessive heat. The solid-state thermistors buried in the windings instantly sense excessive heat from any cause and simultaneously warn of trouble or automatically take the motor off the line. Thus, motor protection is placed where only true motor protection can be . . . in the windings."

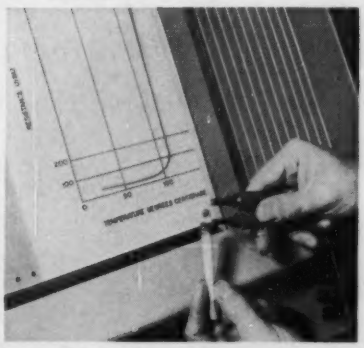
Call your Mr. Westinghouse for the application of a Guardistor* motor to your drive requirements . . . write for *Questions and Answers About . . . Guardistor* (B-7876). Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

*Trade-Mark

J-22160



Unlike remotely located sensing devices, PTC thermistors are buried in the windings of the Guardistor motor, instantly equating all temperature factors.



Ever alert PTC thermistors constantly totalize temperature, statically triggering an action *only* if critical temperature is reached.

MOTOR & GEARING DEPARTMENT

YOU CAN BE SURE...IF IT'S

Westinghouse

TUNE IN WESTINGHOUSE-CBS TV-RADIO COVERAGE, PRESIDENTIAL CONVENTIONS, JULY 10-29

Circle 440 on Page 19

Send for free brochure, PARTLOW CONTROLS... A handy, condensed catalog of the complete line of Partlow temperature controls and allied equipment for industrial heating and refrigeration.

FAST, ON-TARGET DELIVERIES . . .

Another reason why more firms than ever are using Partlow Temperature Controls

Much of Partlow's business involves special controls to solve special application problems.

No matter how off-standard the control, however, the odds are better than 99-to-1 that the Partlow you order will be delivered well within our regular 3-to-4 week schedule. During the past 12 months — the busiest in our 40-year history — 99% of all the controls we produced went out *on time*, or ahead of it!

Of course, prompt, dependable delivery is only one reason for the mushrooming demand for Partlow products. Here are a few others:

Mercury Actuation, which lets the Partlow function without an outside power source or temperamental electronic amplification . . .

Unmatched Design Simplicity, which enables the Partlow to withstand even extreme conditions of shock, vibration, corrosion, dust and moisture, without loss of accuracy or sensitivity . . .

Interchangeability of Elements, which makes it possible for any Partlow to be serviced at the job site, virtually eliminating "down time."

Partlow makes a complete line of electric, mechanical and pneumatic controls (recording, indicating and non-indicating) for temperatures up to 1100°F. Whatever your application problem, Partlow makes an instrument to handle it efficiently, economically, *precisely*. Write for details: The Partlow Corp., New Hartford, N. Y., Dept. D-760.

PARTLOW
TEMPERATURE CONTROLS

World Export:
Ad. Auriema, Inc., 85 Broad Street, New York 4, N. Y.

Circle 441 on Page 19

"CRONAFLEX® gives us better reproductions; cuts processing time for reproducibles 73%"

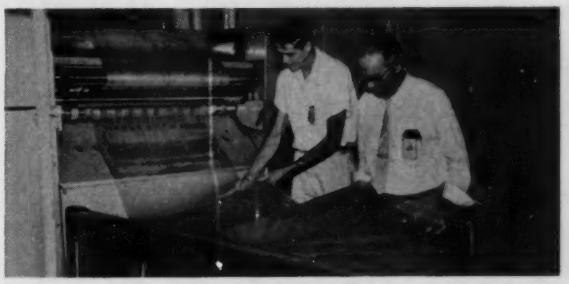
—W. H. Eckhart, Chief Design Engineer, Portsmouth Naval Shipyard

A new blueprinting machine with special lighting features and additional tanks for photographic processing has been installed at Portsmouth Naval Shipyard. Not only does this machine process conventional blueprints, but it also produces photographic second originals on CRONAFLEX in a continuous process.

"CRONAFLEX Direct Positive Film has almost completely eliminated our need for the conventional intermediate negative. Work that previously took two employees 104 man-hours is now done in 14 hours. We have eliminated the negative material and the man-hours necessary for the processing and spotting of these intermediates. In all, we feel CRONAFLEX has, by its photographic versatility, increased our production of reproducibles 400%," according to Mr. Eckhart.

He continues by saying, "The Shipyard's experience shows still other CRONAFLEX advantages, such as moisture resistance and the durability of the rugged CRONAR® base. For example, the fast drying of the "Cronar" base saves us many production hours. The reproductions are ready immediately for blueprinting when they leave the machine, resulting in increased blueprint production and the release of 315 square feet of floor space previously needed for air drying."

CRONAFLEX Films can cut costs in *your* operation. For information or a demonstration, contact your Du Pont Technical Representative or write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.



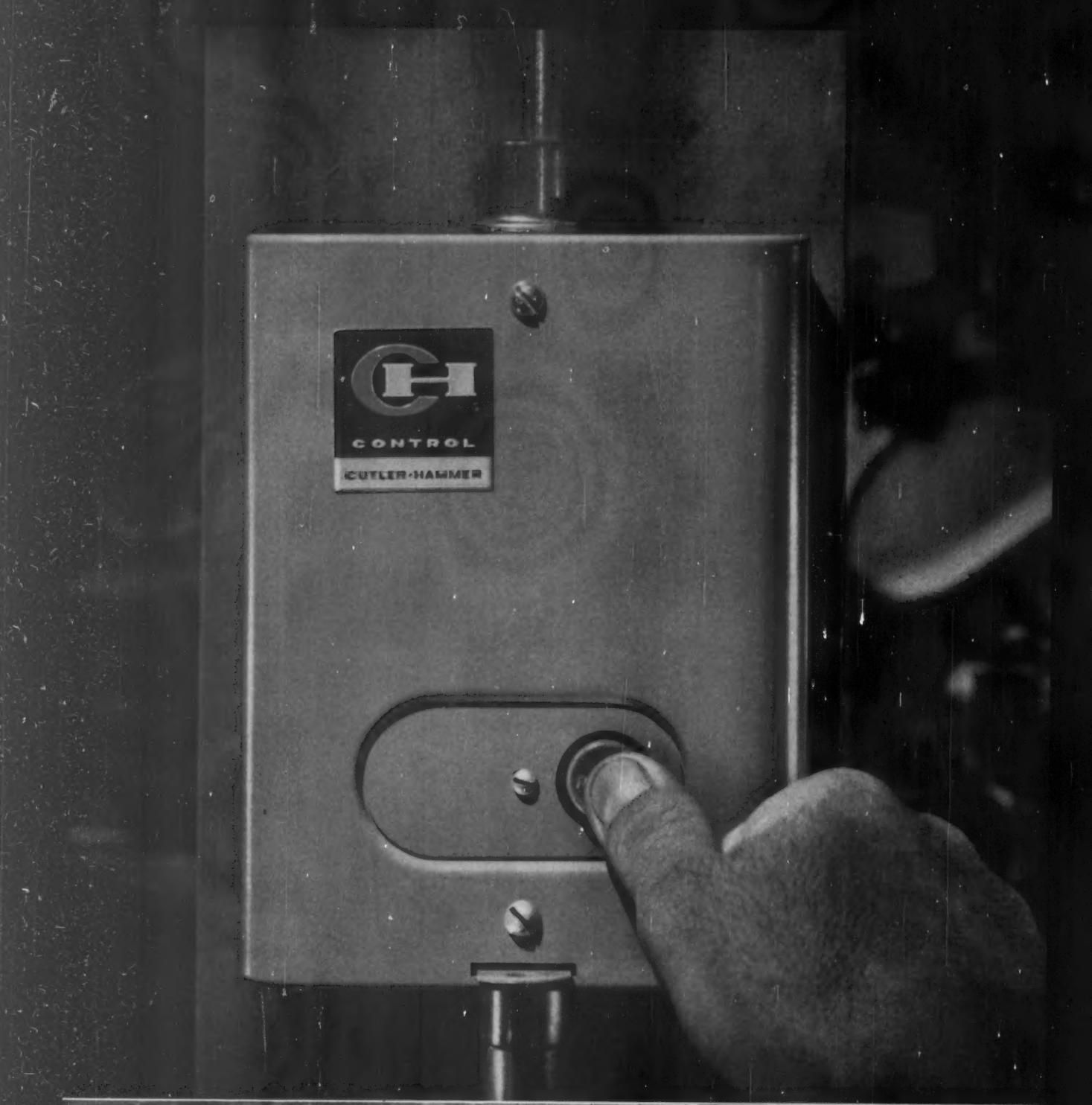
The moisture-resistant, fast-drying polyester base makes CRONAFLEX a natural for this continuous system where reproductions are fed through five rapid-drying drums ranging from 100 to 140° F.

Portsmouth Naval Shipyard experts inspect a reproduction on CRONAFLEX. Left to right: C. R. TUTTLE, JR., *Engineering Draftsman;* W. H. ECKHART, *Chief Design Engineer;* E. H. MARCOTTE, *Supervisory Naval Architect.*

DU PONT

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

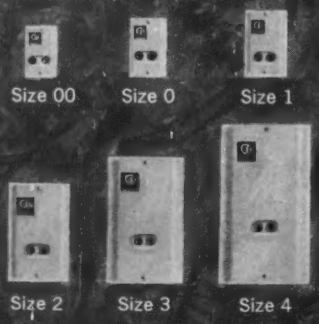
Circle 442 on Page 19



Smaller! About 20% smaller than Size 0 Starters. Just 5 3/4" wide, 7" high and 4 3/16" deep.

Convertible! Carried in stock with three cover options or easily converted in field from "reset" only to "start and stop-reset" or "three-position selector switch." Kits at optional cost.

Broad line!



A new addition to the famous three star line

New! Save space and money with Cutler-Hammer's Size 00 A-C Magnetic Starter

Takes up to 20% less space... costs 18% less than Size 0 Starters. Now you get two big new bonuses in control selection . . . less space and less money Both with the all new Size 00 Starter.

Before, you had to use a larger starter in applications where it really wasn't needed. But, now you can use the Size 00 in about 40% of the applications where the Size 0 is usually used.

The new Cutler-Hammer Size 00 Starter performs to the same high standards you get from all Cutler-Hammer Starters. And, you still get vertical, dust-free contacts which add so much to more reliable starter performance. Your choice too, of 2-coil or 3-coil overload protection in the same small enclosure.

The Bulletin 9586 Size 00 Starter can be used on any general application. Its maximum horsepower ratings: Three phase: 208/220 volts, 1½ hp. 440/550 volts, 2 hp. Single phase: 115 volts, ⅓ hp. 230 volts, 1 hp. It's available open or in NEMA 1 enclosure. Send for Pub. LO-40-N243.

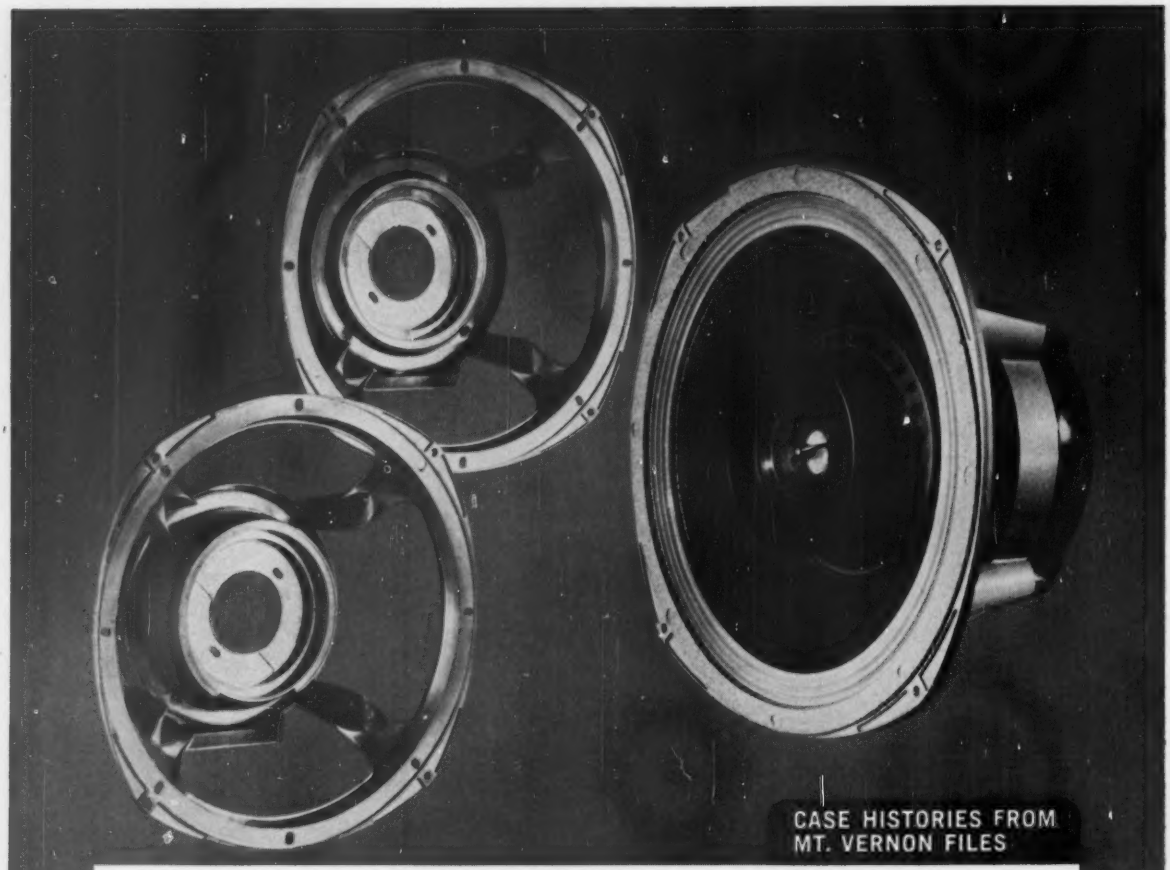
Why you get more from Cutler-Hammer. New things are happening at Cutler-Hammer—new, better products, new engineering ideas and talent, new plant capacity. We're on the move. And, we'd like to show you how we could help you in any electrical control problem. Contact the nearest Cutler-Hammer distributor.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A

Circle 443 on Page 19



From 1 Mt. Vernon Die... 2 Castings...7 University Speakers

This University* Loud Speaker basket won first prize in the New Jersey Zinc Company "Lighter Than You Think" Die Casting Contest. It is one of two castings used to produce all seven new University wide range Series 200 speakers.

The basket weighs only 2 lbs. 12 ozs; measures 13" across corners; is 4⅝" deep and has a minimum wall thickness of .040". It is a one-piece, non-magnetic zinc casting that provides perfect rigidity for the entire structure assuring life-long stability and reliability. Furthermore, its narrow struts offer a minimum of reflecting surfaces, thus avoiding unwanted peaks and valleys in the frequency response of the speakers.

University engineers, thoroughly familiar with inherent advantages of die casting, design for maximum effectiveness of the art. The result ... an ingenious Mt. Vernon die with *interchangeable cores enabling them to cast two modified baskets from one die.* And because they have been working with Mt. Vernon for many many years, they dare to try the unconventional approach knowing full well that they can always depend on Mt. Vernon to follow through.

You may not be trying to win prizes ... just aiming for lower production costs. In that case we can show you how it can be done with die castings. Just call your nearest M.V. Sales Representative for quick action.

*University Loudspeakers, Inc., White Plains, N.Y.

MT. VERNON DIE CASTING CORPORATION
STAMFORD, CONNECTICUT

SALES REPRESENTATIVES

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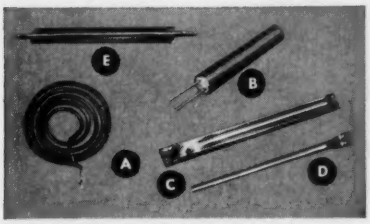
SKANEATELES, N. Y.: Mr. Jerome J. Theobald, 9 E. Genesee St.
STAMFORD, CONN.: Mr. Anker Anderson, Cascade Road
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115

Surface Heating Guide

How to choose electric heaters of the right type and size for your design

Here is condensed information to help you get the most economical electric heater for your surface heating design problem.

Two factors generally determine which type heater should be used for any particular surface-heating application. They are: the physical characteristics of your product, and the surface temperature required.



General Electric *tubular heaters* (a) can be formed to unusual shapes and may be "cast in metal" as part of your product during manufacture. They may also be located in grooves, inserted into drilled holes, immersed in liquids, wrapped tightly around the surface or spaced away.

G-E *cartridge heaters* (b) are ideal for "spot" heating of small areas. Short and compact, they can be easily inserted into drilled holes within the machine or surface.

For flat metallic surfaces, such as hot plates, platens and dies, *strip heaters* (c) may be clamped on or spaced away. General Electric *insertion heaters* (d) are ideal for heating hollow bolts for high-pressure steam-shell joints to prevent steam leakage.

For warming tables, and preheating plates, G-E *vane heaters* (e) may be clamped on or spaced away.

To figure the amount of heat required for your application:

1. Find the volume in cubic inches of the material in process.
2. Figure needed temperature rise in degrees F (subtract initial temperature of material from desired final temperature).
3. Find heat absorbed by material (Table 1 applies to all materials except those listed in Table 2). Values from Table 2 should be added or subtracted from values in Table 1 to correct it.
4. Determine the total surface area of the platen.
5. Using this area and the desired final temperature, check Table 3 to get heat losses of platen.
6. Add kilowatts computed in Step 3 to those computed in Step 5. You now know how much heat is required.

For complete information on sizes and ratings of General Electric heaters, send coupon below.

DELIVERY TODAY: Popular sizes of General Electric heaters are available today from General Electric stocks near your plant.

SPECIAL SAMPLES: Your General Electric sales engineer can advise you on special heating problems. If special heaters are required, he will provide samples.

PROMPT SHIPMENT: General Electric's new Industrial Heating plant at Shelbyville, Indiana, is now geared to give excellent shipping dates on heaters for your production needs. Just call your nearest General Electric Apparatus Sales Office and tell us your requirements. General Electric Company, Schenectady 5, New York.

TABLE 1—HEAT ABSORPTION IN KILOWATTS OF MATERIAL IN PROCESS

Volume of Material in Process (cu. in.)	Temperature Rise in °F					
	50	100	150	200	250	300
1	.006	.012	.018	.024	.030	.036
5	.030	.060	.090	.120	.150	.180
25	.090	.180	.270	.360	.450	.540
100	.360	.720	1.08	1.44	1.80	2.16
500	1.80	3.60	5.40	7.20	9.00	10.8
1000	3.60	7.20	10.8	14.4	18.0	21.6

TABLE 2 CORRECTION FACTOR

Material in Process	Subtract or Add % as indicated to figure in Table 3
Aluminum	−30%
Dry Wood or Paper	−50%
Wet Wood or Paper	+20%
Glass	−40%
Rubber	−30%

This table is based on a ten minute working cycle. If working cycle is other than 10 minutes use following formula to correct values: 10 divided by the number of minutes in the cycle times the kilowatts given above equals the kilowatts at the new cycle. Table 1 will apply for all materials except for those listed in Table 2. Apply correction factor if needed.

TABLE 3*—PLATEN HEAT LOSSES IN KILOWATTS

Surface area of metal platens in sq. inches	Final temperature in degrees F of metal platens			
	100	200	300	400
100	.024	.080	.160	.280
250	.060	.200	.400	.700
500	.120	.400	.800	1.40
1000	.240	.800	1.60	2.80
2000	.480	1.60	3.20	5.60
3000	.720	2.40	4.80	8.40

*This table based on platens being completely uninsulated.

GENERAL ELECTRIC

Section H723-12, General Electric Co.
Schenectady 5, New York

Please send GEA-6146, Surface Heating Handy Selector Guide and GEC-1005, Catalog of G-E Heaters and Devices.

NAME _____

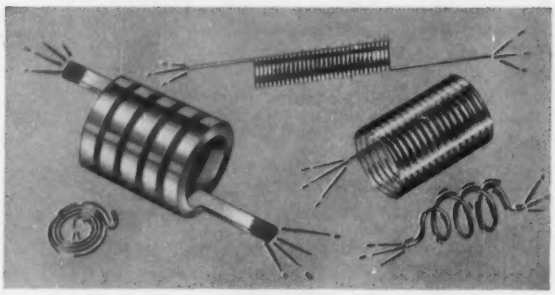
COMPANY _____

ADDRESS _____

CITY _____ STATE _____

Circle 445 on Page 19

Design may be affected when springs must carry current.

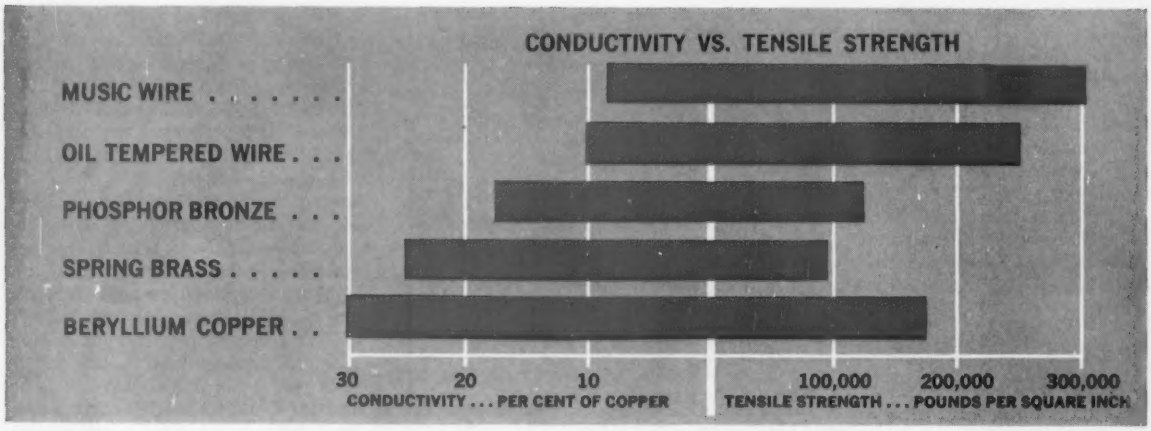


Good electrical conductivity or low electrical resistance of spring materials must be considered in relation to working stresses. When springs must carry current with a minimum of heating, the copper base alloys offer the most logical choice for the spring material. But most of these alloys are relatively low in strength, and the elastic modulus is low also. Since both the strength and modulus affect the design, conductivity and stress must be taken into consideration right at the start.

This conflict between conductivity and strength may be better understood by referring to the bar chart. Here, the bars to the right of the vertical line show the approximate relative tensile strength while the bars to the left indicate relative electrical conductivity of commonly used materials.

Requirements for good conductivity mean generous cross sections and low stresses which minimize the creep tendency of constantly stressed springs.

A.S.C. research and experience is at your service in all fields of spring usage. Write for your copy of "Spring Design and Selection — in brief."


CONDUCTIVITY VS. TENSILE STRENGTH
MUSIC WIRE . . . . . .
OIL TEMPERED WIRE . . .
PHOSPHOR BRONZE . . .
SPRING BRASS . . . . .
BERYLLIUM COPPER . .
30
20
10
CONDUCTIVITY . . . PER CENT OF COPPER
100,000
200,000
300,000
TENSILE STRENGTH . . . POUNDS PER SQUARE INCH

5809

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
F. N. Manross and Sons Division, Bristol, Conn.
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
Cleveland Sales Office, Cleveland, Ohio
Chicago Sales Office, Chicago 46, Ill.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Mattoon, Ill.
Milwaukee Division, Milwaukee, Wis.
Seaboard Pacific Division, Gardena, Calif.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

Circle 446 on Page 19

New, bigger selection of VICTOR SHEET PACKINGS

Catalog 505A now being supplied to specifiers and buyers

Covers all standard compositions of asbestos, plant and cellulose fibers, cork and synthetic rubber—in various grades, including metal-core constructions

Sealing specifications come easier with this catalog at hand. It gives you all essential data to make the best choice of modern gasket packings for industrial applications—automotive, machinery, appliance, aeronautical and marine.

Right up front, this complete specification manual gives you both new and old SAE-ASTM classification numbers to which each Victor material in its various grades conforms.

Choosing from this catalog insures your intent of performance and value—Victor quality control sees to that! Also, you're assured of prompt availability —sheet packing or die-cut gaskets—by Victor's unmatched facilities.

Victor Mfg. & Gasket Company, P.O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ont.

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Company_____

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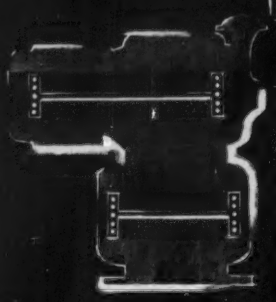
Sealing Products *Exclusively*

GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS

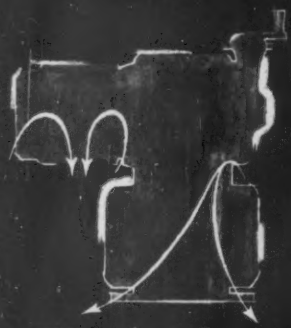
Field Versatility

Mounting feet, end brackets, control hand wheel, conduit box, and output shaft can be relocated in minutes without special tools for wall-, floor- or ceiling mounting. Components can be changed or controls can be added in the field to meet ever changing conditions of operation.



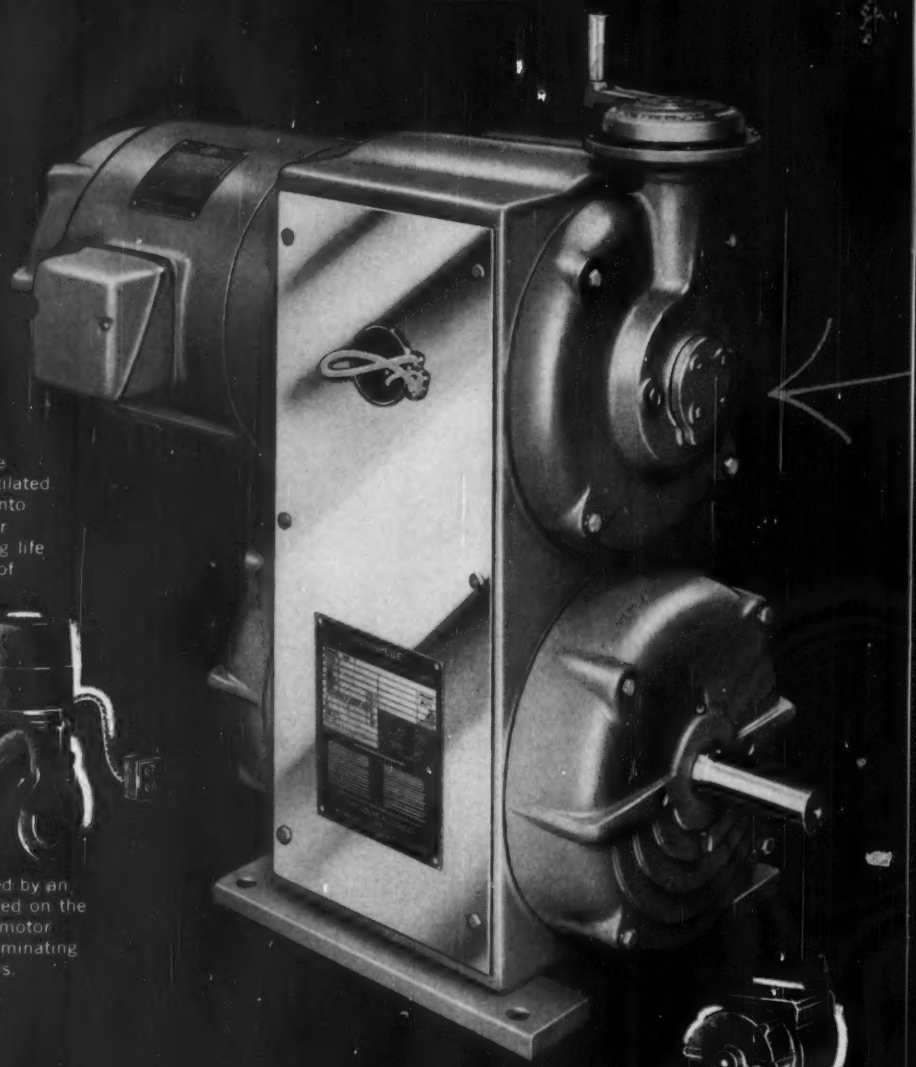
Four-Bearing Design

This important design feature eliminates the problems of overhung discs. It equalizes distribution of belt loading — keeps bearings, shafts, discs and belt permanently aligned — improves performance — and extends bearing life.



Dual-Ventilation System

The motor and the belt housing of the ALLISPEDE DRIVE are individually ventilated. Motor ventilating air is not exhausted into the belt housing — belts run cooler for longer life. Service factor and operating life of all components are higher because of lower operating temperatures.



Trouble-Free Remote Control

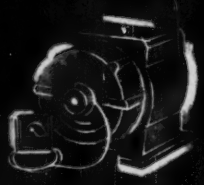
Electrical remote control can be provided by an enclosed speed-adjusting motor, mounted on the belt-changing mechanism. This torque motor can be stalled without overheating, eliminating the need for troublesome limit switches.

Long Belt Life

Single-cog belts with extra contact area provide more efficient transmission of power and longer belt life. Dual ventilation, precision machined discs, equalized loading, and automatic belt tension aid in extending belt life.

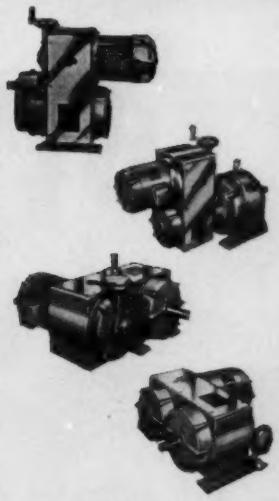
Fast Belt Changing

Belt changing is fast and easy — without requiring special tools. You remove only one bearing bracket and the speed adjusting mechanism to make fast changes without affecting permanent alignment of discs or belts.



Remote Speed Indication

A tachometer generator mounted on the output shaft operates an indicator that can be mounted at a remote location. Disassembly of the tachometer is not required when making belt changes.



Four of the many variations of mounting available with the ALLISPEDE DRIVE.

Another new product from Louis Allis

Let's look at the features of the ALLISPEDE DRIVE*

New Louis Allis Drive offers accurate control – maximum belt life – long-run economy – low-cost versatility – ease of installation

After checking the many superior features of this drive, you will prefer the Allispede every time. The illustrations at the left demonstrate the many advantages of design and construction available in this drive.

The Allispede Drive gives you high efficiency and close regulation. Belt tension adjusts automatically — and belt changes are easy and fast. The modern design eliminates overhung discs—maintains belt and disc alignment — results in longer belt life — provides the ultimate in field versatility.

Check the accompanying features — *now!* A phone call to your local Louis Allis District Office will bring a skilled Louis Allis Field Engineer. He will gladly study your drive problem and offer Application Engineering assistance. Or write to Louis Allis Company, 459 East Stewart Street, Milwaukee 1, Wisconsin for a copy of Bulletin 3600.

*ALLISPEDE is a trademark of The Louis Allis Company.

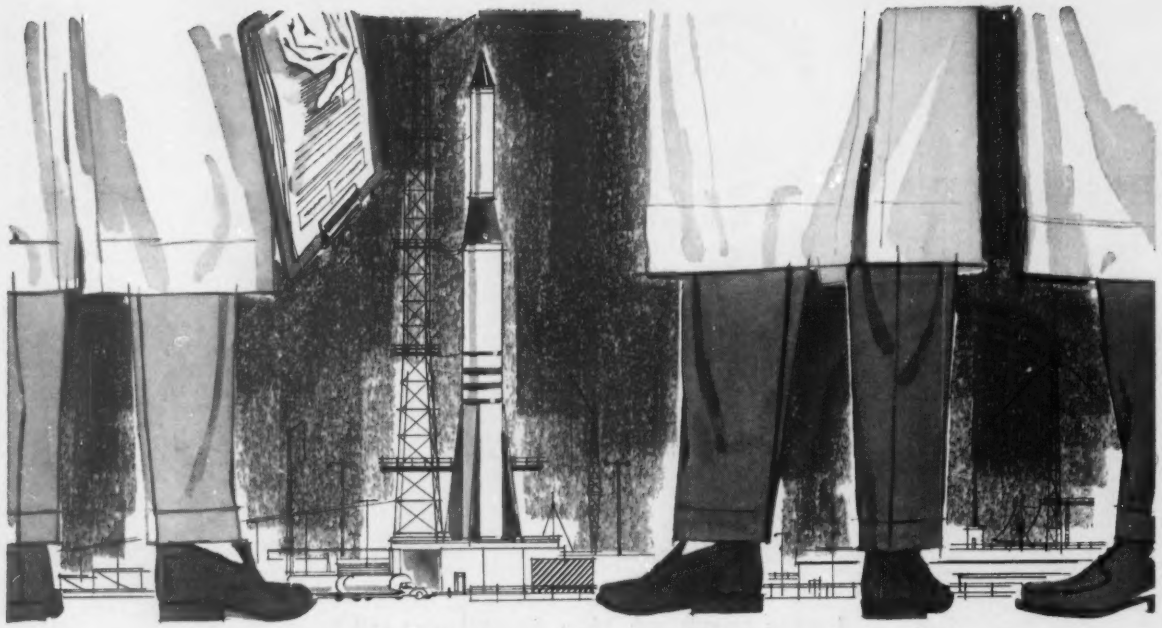
The Complete Line–

Whatever your mechanical drive application requirements, there's an ALLISPEDE DRIVE to match it exactly. Sizes up to 30 HP, output speeds from 1 to 10,000 RPM, and speed ranges up to 8:1. Motors can be open, drip-proof, enclosed, or explosion-proof; with ventilated or enclosed belt housings, suitable for foot, P-base, C- or D-flange mounting on your machine. Available with parallel shaft, or right-angle, integral gear reducers, special shaft extensions, integral magnetic brakes, electrical or mechanical remote control, and other modifications as required to meet the specifications of your application.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

Circle 448 on Page 19



It takes feet on the ground

And this is exactly what Lear technology offers industry . . . The same solid background of practical, precise, yet imaginative engineering already proven in the aircraft and missile field. Product quality and reliability are only part of what you can expect from Lear industrial components and systems. Combining basic engineering with development and research facilities, you receive *complete* service in any stage, in any area, of automation planning. We invite you to take full advantage of these unequalled resources. Write or call today.

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Circle 449 on Page 19

New Design Opportunities Through Aluminum Forgings

STEEL CONNECTING ROD ASSEMBLY

ALUMINUM CONNECTING ROD ASSEMBLY

Both of these connecting rods were designed for use in the same automotive air conditioning compressor.

WHICH CONNECTING ROD COSTS LESS?

One glance tells you it's the aluminum connecting rod at the right. Two pieces are easier and less expensive to fabricate than five.

By designing this connecting rod as a Kaiser Aluminum forging, Lennox Tool & Machine Builders of Lima, Ohio, cut costs for their customer, Airtemp Division, Chrysler Corporation.

The steel connecting rod formerly used required five different pieces, including three bronze inserts for wrist pin and crankshaft bearings, plus two connecting rod bolts. Plenty of precision machining was also required.

The new aluminum connecting rod consists of only two pieces, plus the two connecting rod bolts. For this part, the forging itself was bored to provide a hard mirror-finish surface for wrist pin and crankshaft bearings, thus eliminating the three bronze inserts.

Strength? The aluminum forging meets every strength and dimensional stability requirement specified for the compressor application. In fact, the life expectancy of forged aluminum rods and steel rods with bronze insert is virtually the same!

This is another example of how strong, lightweight Kaiser Aluminum forgings can simplify design and cut material, machining and assembly costs. To find out how Kaiser Aluminum forgings can save you money, mail the coupon now!

KAISER ALUMINUM

THE BRIGHT STAR OF METALS

*TRADEMARK KAISER ALUMINUM & CHEMICAL CORP.

Kaiser Aluminum & Chemical Sales, Inc.,
Dept. FO-124M, Kaiser Center
300 Lakeside Drive, Oakland 12, Calif.

Please send me the latest aluminum forgings design packet describing the many advantages of aluminum forgings for commercial use.

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COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

THESE 13 SPECIAL ALLOYS FROM *can help you solve design problems . . .*

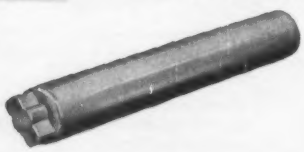
As the result of the knowledge gained over the years by working closely with hundreds of customers in helping solve innumerable design and production problems, the Mueller Brass Co. has developed a series of special alloys for use in tough or unusual applications.

This group of special alloys, each having distinct characteristics and advantages, are available in rod form in many sizes and shapes as well as forgings.

CHARACTERISTICS AND APPLICATIONS	ALLOY NO.	NAME	TEMPER
TUF-STUF® ALUMINUM BRONZES AND NICKEL ALUMINUM BRONZES have great strength characteristics. All are more resistant to corrosion cracking under load than copper-zinc alloys and, in addition, some are heat-treatable. They can withstand heavy pounding and have proved excellent for such parts as gibs, cams, valve seat inserts, shifting forks and propeller hub cones.	224E-30	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 165
	224E-75	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 175
	224C	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 185
	224H	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 200
	224K	"Tuf-Stuf" Nickel Aluminum Bronze	BRINELL 3000 KG load 250
ALUMINUM SILICON BRONZE is free turning; has high strength, is corrosion resistant and non-magnetic and resistant to corrosion cracking under load.	802	Aluminum Silicon Bronze	ROCKWELL-B 75
600 SERIES® FORGEABLE BEARING ALLOYS range from high strength to low loaded ductile. All are corrosion resistant, free cutting, can be used with hard or soft mating members and can be soldered. They are employed in a great variety of applications ranging from pump gears and valve stems to pinion shafts and transmission rings.	600	Forgeable Bearing Alloy	ROCKWELL-B 88
	601	Forgeable Bearing Alloy	ROCKWELL-B 87
	602	Leaded Forgeable Bearing Alloy	ROCKWELL-B 87
	604	High Leaded Forgeable Bearing Alloy	ROCKWELL-B 86
	605	Low Leaded Forgeable Bearing Alloy	ROCKWELL-B 80
MANGANESE BRONZE ALLOYS are exceptionally strong, tough, resistant to shock and corrosion. Good for screw machine products and forgings for aircraft parts.	241A	Manganese Bronze A	ROCKWELL-B 85
	721	Manganese Bronze High Tensile Grade B	BRINELL 1000 KG load 200
TELLURIUM COPPER has very high electrical and thermal conductivity combined with good corrosion resistance and machinability. Excellent for electronic components.	799	Tellurium Copper	ROCKWELL-B 45

NOTE: The values shown are average values normally obtained in production. Variations must be expected in practice. The values should be used as a general guide rather than the basis for specifications.

ONE DEPENDABLE SOURCE FOR



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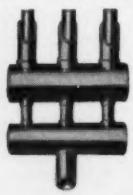
SINTEEL® POWDERED METAL PARTS



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MUELLER BRASS CO.

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lower costs and improve your products

Mueller Brass Co. engineers and metallurgists are always ready to assist in the selection of the proper alloy for your particular product.

Regardless of your responsibility... design, specification, production or purchasing... Mueller Brass Co. special alloys can help you lower costs and improve your products. Call the "Man From Mueller Brass Co." today and put these remarkable alloys to work on your toughest jobs.

Yield Strength at 0.5% Extension Lbs./Sq. In.	Tensile Strength Lbs./Sq. In.	Relative Machinability Free Cutting Brass=100%
50,000	82,000	30
65,000	100,000	30
62,000	95,000	35
70,000	90,000	30
65,000	105,000	20
35,000	85,000	60
60,000	90,000	25
55,000	78,000	35
65,000	85,000	65
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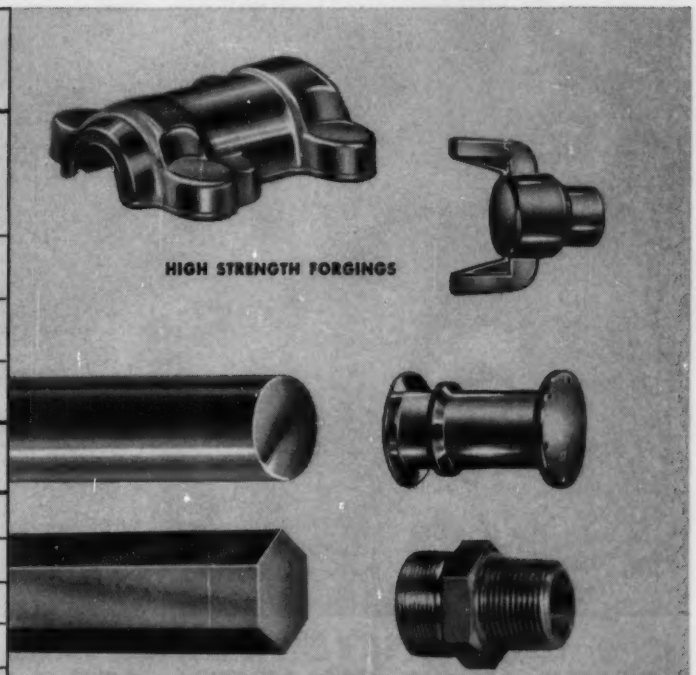
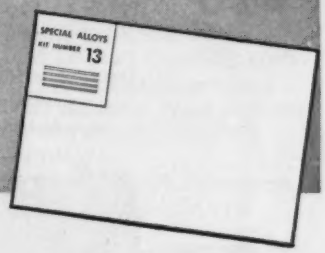
45,000	70,000	55
55,000	78,000	25
68,000	115,000	35
40,000	43,000	90



HIGH STRENGTH FORGINGS

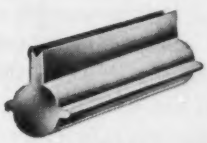
ROD SHAPES FOR SCREW MACHINE PRODUCTS

For further information on these alloys write today for Special Alloys Kit No. 13. Engineering information on other fabricated products is also available... please specify the manual you desire.



ALL THESE QUALITY PRODUCTS

SAND CASTINGS



CUSTOM EXTRUDED PLASTIC SHAPES AND INJECTION MOLDINGS

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

PORT HURON 20, MICHIGAN

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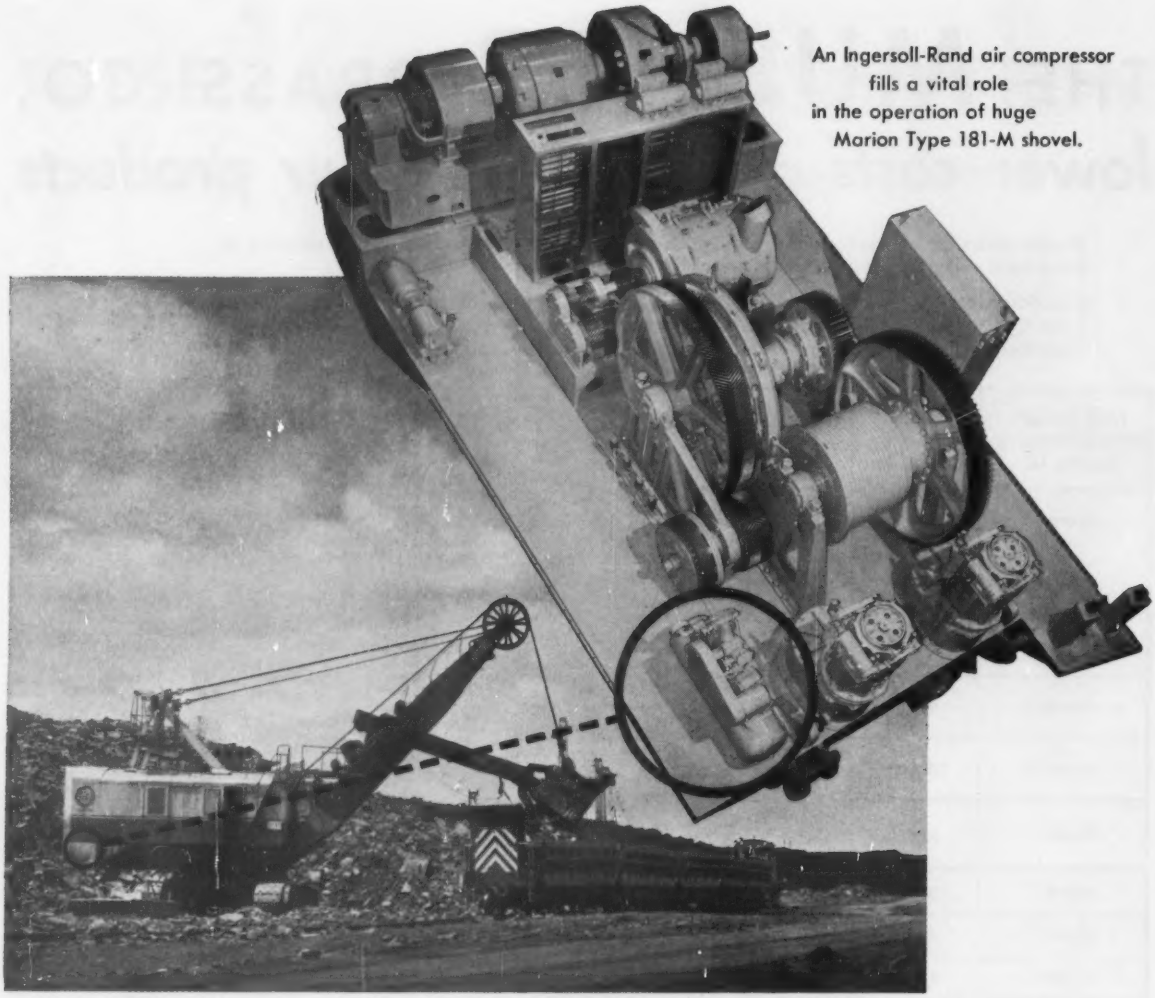
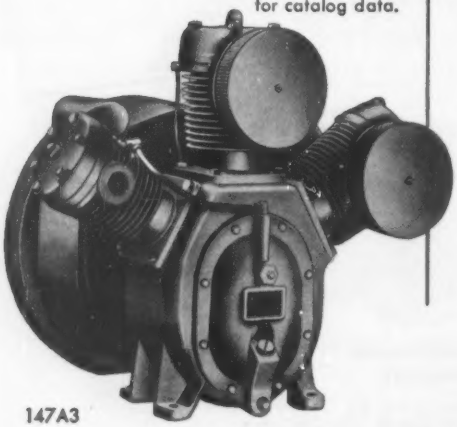


An Ingersoll-Rand air compressor fills a vital role in the operation of huge Marion Type 181-M shovel.

design with Ingersoll-Rand for dependability

Get complete details from your Ingersoll-Rand representative or write for catalog data.



147A3

Equipment designers and product engineers can match their most rigid specifications from this *complete* line of Ingersoll-Rand air-cooled air compressors. Top efficiency and operational economy plus important savings in space and weight make I-R compressors the top choice for dependable components.

Ingersoll-Rand air-cooled air compressors are available as bare units, baseplate mounted or tank mounted in sizes ½ through 20 hp. In addition, I-R can furnish high pressure compressors, non-lubricated compressors and vacuum pumps.

Ingersoll-Rand

11 Broadway, New York 4, N.Y.

Circle 452 on Page 19

STANSCREW

Symbol of a new concept

in fastener service

American industry is learning Stanscrew means extra values.

This symbol personifies a trained staff of fastener specialists. Their technical assistance can often help you reduce fastener and assembly costs.

It means extra quick deliveries from complete inventories maintained at three conveniently located plants . . . over 5,000 different types and sizes to assure a broad selection for the great majority of your requirements . . . and, above all else, fasteners of consistently high quality.

Although it first appeared in 1958, the Stanscrew trademark represents a wealth of fastener experience. For it combines the technical skills and specialized facilities of three major manufacturing divisions of Standard Screw Company, each an honored name for more than 80 years. They are:

THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

For fasteners, specify Stanscrew. For other needs of home and industry, Standard Screw divisions also produce:

Moen single-handle faucets • Hartford textile spindles
Roosa Master fuel injection pumps • Chicago tappets

Each division also provides a complete design and manufacturing service for cold headed and screw machine products.

STANDARD SCREW COMPANY
2701 Washington Boulevard • Bellwood, Illinois

Circle 453 on Page 19

OZALID NEWSLETTER

NEW IDEAS TO HELP YOU WITH ENGINEERING REPRODUCTION AND DRAFTING

Standard materials, plus new thinking, result in big time and cost savings.

How to break the halftone costs barrier

Some of the sharper repro men looking to cut the high cost of using halftones in quantity have come up with this little timesaver that goes for pennies per halftone. Here was the problem: 200 rush copies of 16 technical photographs were needed for a service manual . . . a total of 3200 prints. This job would usually run about $2,000 and take ten days . . . that was too long and cost too much.

A bright lad thought about their Ozalid whiteprinting equipment and worked out this procedure: First an 8" x 10" screened film positive was made by projection from a 4" x 5" negative, emulsion away from emulsion. This insured proper orientation of the print in the final stage.

Next, the film positive and Ozalid black-line plastic-coated paper (105SZ) were processed in an Ozalid Printmaster 810 at a rate of 12 feet per minute. The 42-inch width of this machine permitted two operators to work simultaneously, cutting total production time virtually in half! The choice of Ozalid paper Type 105SZ was an excellent one. It gave crisp, black-line images of great density due to the paper's plastic coating. The entire project took just under a fast six hours instead of the usual ten days, and cost about $100.

Total savings: $1900 and 9½ days of production time. Pretty smart, we think. By the way, we've got sample packages available for the asking that might very well give you the same dramatic results. Why not write us at Ozalid, Box S-7, Johnson City, New York. We'll be glad to help.

Looking for a fast case of the blues?

The happy kind, we mean. The clean, rich, decisive blue image that Ozalid's new Super-Speed Blue-Line (200SS) gives. And when we say fast, that's exactly what we mean. *Poor originals are copied up to ten feet per minute faster than with regular copy papers.*

This is the first Ozalid copy paper specifically designed for copying semi-opaque originals at higher speeds . . . at no sacrifice of line density in any sense!

But what does all this mean in practical benefits, other than increased production at no loss in quality?

Well, for one thing, it means that you can now do a fine job on semi-opaque material, such as one-sided letters, documents and bulletins, at the lowest cost of any copying process . . . even if they're printed on bond papers!

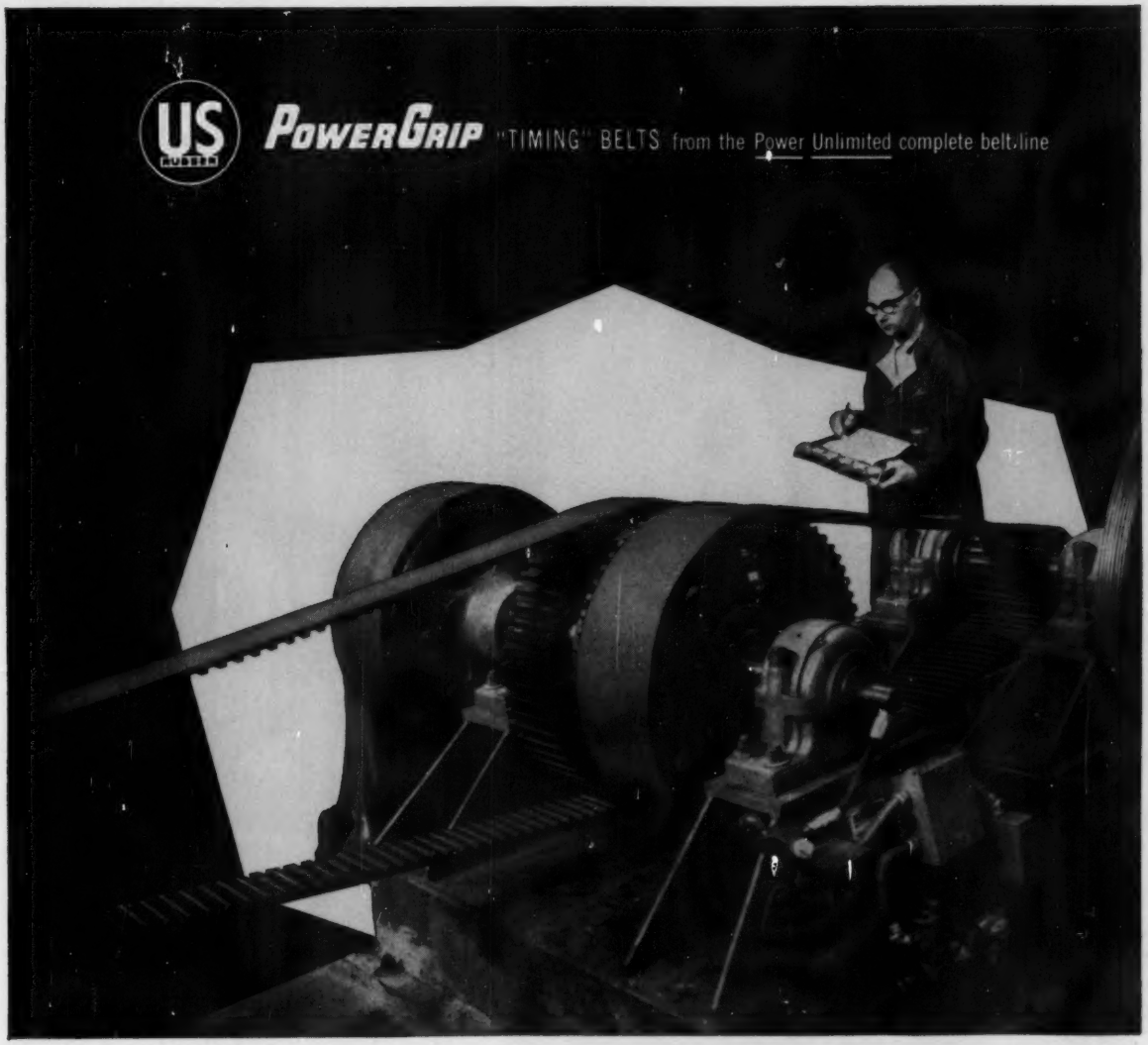
Another benefit is the clean, readable copies you can now produce from soiled, yellowed documents and low-translucency materials much faster than ever before.

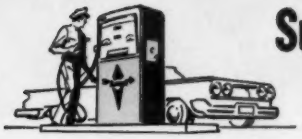
Is that all? Not by a long shot. 200SS actually turns low-powered ultraviolet machines into pretty fast units. And the faster printing speeds mean faster return of the original after each cycle.

Why not try this superb, high-density blue-line paper today? It really makes sense. Just call your local Ozalid representative for a demonstration.

***Ozalid,** Johnson City, New York. A Division of General Aniline & Film Corp.*

Circle 454 on Page 19





Sun Oil Company obtains positive results with U.S. PowerGrip "Timing" Belts

The octane requirements for cars are determined by the Sun Oil Company with scientific accuracy. The octane ratings of motor fuels are in turn determined with precision. Nothing is left to chance. This is why the motorist can pull up at a Sunoco station and obtain the correct octane blend for his car.

All of this predetermination is done on precision equipment whose universal joint drive shaft is connected to a dynamometer by a 1¼" pitch U. S. Rubber PowerGrip "Timing"® Belt. In the words of a company scientist, these belts were selected because they give foolproof, positive drive transmission and do not require lubrication, maintenance or attention. Anything less would interfere with the precision of the testing equipment. This is the experience that has caused innumerable design engineers to specify PowerGrip.

This is the belt that has made possible the development and production of hundreds of appliances and equipment, ranging from sensitive electronic devices, office machinery, household equipment and gigantic production machinery. One way to get expert and instant power and transmission advice is from the U. S Distributor.

Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

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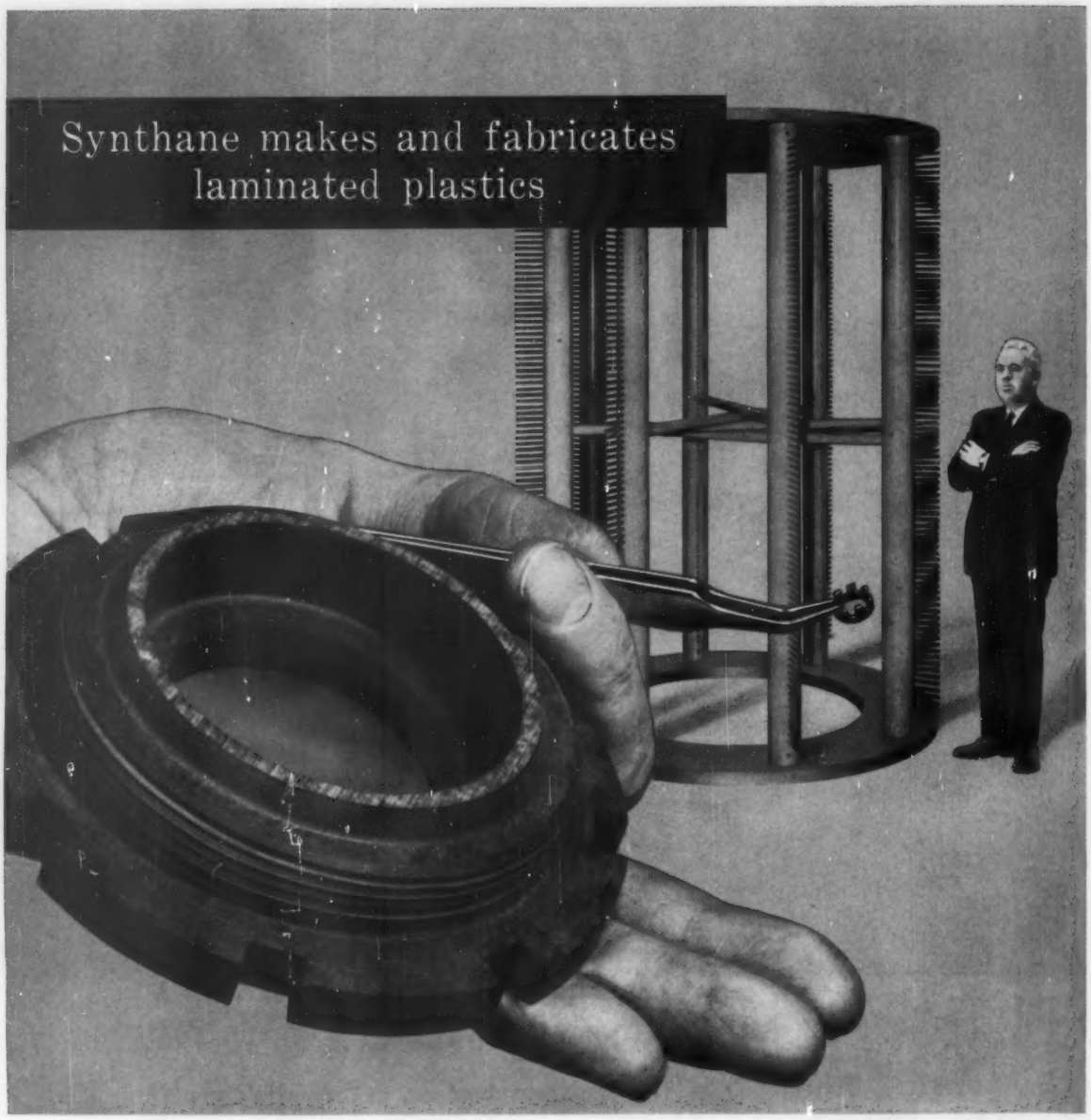


Large, small or in between...we make it

Size is no problem in our fabrication of Synthane laminated plastics. Whether the part fits into your palm or onto the head of a pin, or towers over you, we believe we can handle it.

Why? Because we make the material and can control it to suit the job. Our variety of machines and tools, many of them special, permit the widest freedom in the choice of a machining approach. Our skilled people have rolled up over 30 years of experience in doing the difficult and impossible. So, large, small or medium in size, let us take the production worries of your part off your mind.

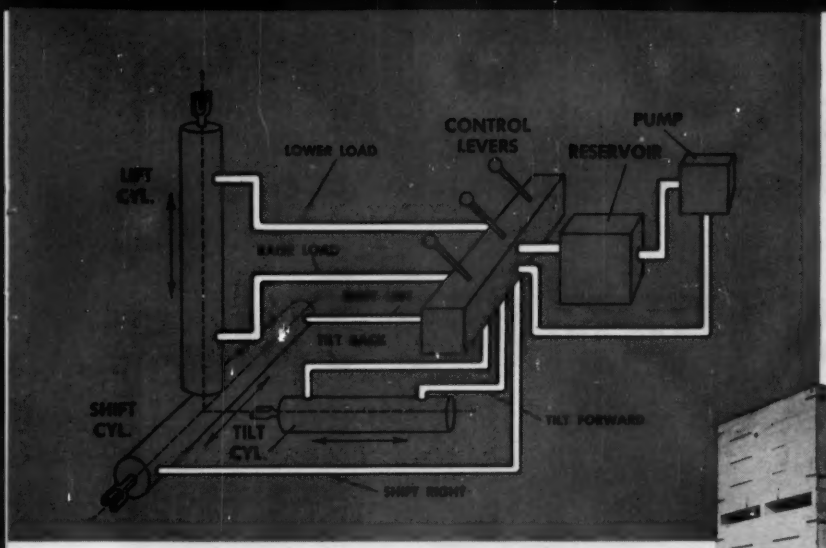
Call your Synthane representative for a quotation or write Synthane Corp. 5 River Road, Oaks, Pa.

SYNTHANE
CORPORATION OAKS, PENNA.

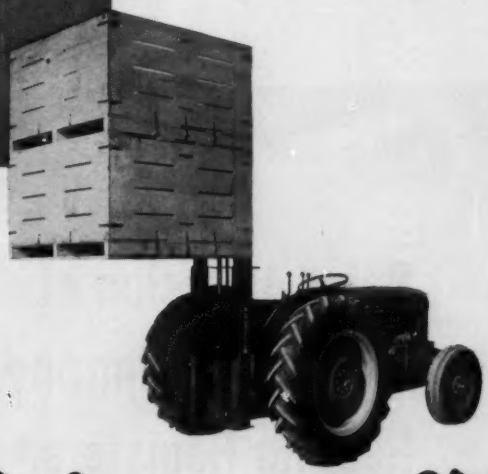
Sheets • Rods • Tubes • Fabricated Parts
Molded-laminated • Molded-macerated

You furnish the print—we'll furnish the part

Circle 456 on Page 19



Schematic drawing of hydraulic system in Blackwelder Fork Lifts, built for every farm material-handling operation. White lines indicate Gates Hose for hydraulic fluid operating lift, tilt and shift cylinders.



Gates Hose helps Blackwelder Fork Lift

lower costs...pick up profits!

"We've been using Gates wire-reinforced hydraulic hoses on our Blackwelder Tractor-mounted Fork Lifts for years," says Fred Hill, Chief Engineer for the Blackwelder Manufacturing Company, of Rio Vista, California, makers of farm material handling equipment. "Their exterior cover and durable inner tube make them ideally suited to withstand the rough abrasion and temperature conditions under which our equipment is operated. We know our hydraulic components will function properly with Gates Hose assemblies, and our customers benefit by keeping maintenance to an absolute minimum!"

Immediately available in all major markets

Gates Hydraulic Hose — built to meet or exceed SAE specifications — is available nation-wide in wire-braided and horizontal-braided construction in a complete range of sizes, for medium-pressure or high-pressure use. Ask your nearby Gates Distributor, for Gates Hydraulic Hose Assemblies booklet, IH 43.

The Gates Rubber Co., Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ont.

Gates

The Mark of *Specialized* Research

TPA 466

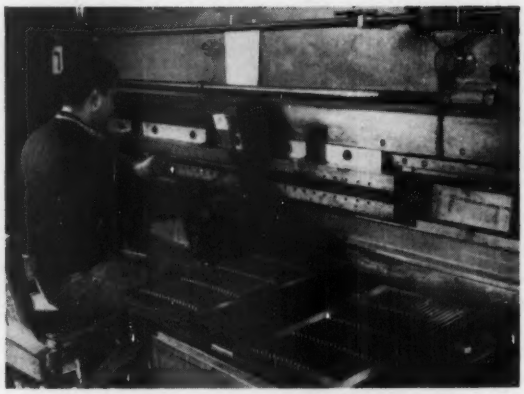
Gates Hydraulic Hose

Made in a Full Range of Sizes
Medium-Pressure, High-Pressure

Circle 457 on Page 19

Superior Pre-Paint Protection Racks Up More Sales,

Paint Adhesion of Air Conditioning and Heating Registers, Grilles and Diffusers Insured by Granodine



Precision forming equipment turns coil stock steel into product at Krueger plant.

At major parts producer, Krueger Air Conditioning Corporation, registers, grilles and diffusers are treated with Amchem Granodine before painting to provide them with what Krueger officials agree is a "superior finish that extends the life of our products."

FINISHING PROBLEM SOLVED

Before selecting Granodine as their standard phosphating treatment, Krueger had tried several competitive processes but were unable to sustain the final quality or eliminate rust from painted products. The results—customer complaints and rejects running up to 10 percent of total production.

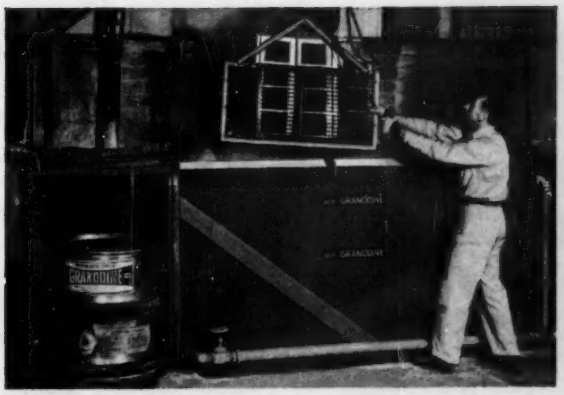
Today, after three years of utilizing Granodine in a five-stage dip phosphating process, Krueger, one of the world's largest manufacturers of registers, grilles and diffusers reports virtually no rejects, increased volume and an all-around better paint finish.

COMPARISONS SELL

To tell their superior finish story Krueger sets up effective side-by-side demonstrations of untreated products and products treated with Granodine at heating trade shows. Customer interest in such displays is high and has led to more sales through

Krueger management-manufacturing team: Left to Right—J. B. Smith, Vice-President of Production; President Leo Krueger; and Ted Kleckner, Vice-President and Comptroller.

# of Amchem GRANODINE*
Fewer Rejects For Krueger



Operator employing electric hoist, lowers load of Krueger products into Granodine dip tank.

Paint line conveyor carries painted Krueger products from water-washer spray booth to inspection area.

graphic illustration of competitive advantages on Krueger's part.

Further support comes to Krueger through the use of Granodine when bidding for and successfully securing Government contracts and projects involving architects where rigid specifications exist for pre-paint finishing.

NEW SYSTEM PLANNED

Looking to the future, Krueger—with a 400 percent increase in sales over the last six years—is currently adding a new 10 acre, 100,000 square foot plant. High on the planning list is a new and virtually completely automated Granodine line. Amchem engineers have designed a unique conveyorized system utilizing overhead cleaning, rinsing and coating of Krueger products which will achieve significant cost savings and substantial reduction in gas consumption through a colder method in the clean-coat phase of the process.

If you are interested in a *superior finish* for steel products—it will pay you to investigate Granodine, the *superior phosphating* process. Your local Amchem Representative can supply the details on how you can quickly and conveniently make the switch to Granodine without interrupting production or re-designing processing facilities, while providing a substantial increase in quality of product finish!

Write for Bulletin 1380B containing detailed information on Granodine for steel . . . the finish that lasts.

*Granodine is Amchem's registered trademark for the conversion coating chemical used to produce phosphate coatings on steel.

AMCHEM® GRANODINE

Amchem is a registered trademark of **AMCHEM PRODUCTS, INC.** (Formerly American Chemical Paint Co.)
AMBLER, PA. • St. Joseph, Missouri • Detroit, Michigan • Niles, California • Windsor, Ont.

THERE'S VIRTUALLY NO LIMIT... *to the Shaft Diameters and Over-all Dimensions of*

MESSINGER PILLOW BLOCKS

Some you can hold in the palm of your hand; others require heavy-duty cranes to lift them in position; but regardless of size, they are completely engineered by Messinger craftsmen to assure faultless performance for many years.

DIAMETERS OF 25" AND LARGER

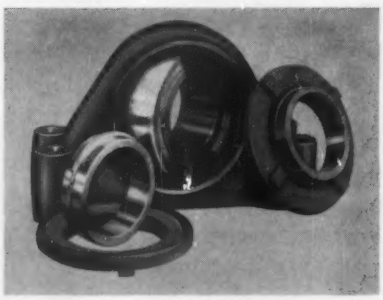
DIAMETERS OF 25" AND LARGER for installations like the "sheaves" of the Houghton—Hancock Bridge between Houghton and Hancock, Michigan. Eight Messinger Pillow Blocks, four on each side, contribute to the smooth operation of this vertical lift bridge. Each Pillow Block measures 72.00" x 56.00" x 39.63", 25.50" diameter shaft.

* * * *

Features of all Messinger Pillow Blocks include exceptional compactness; efficient oil seals; automatic flood oiling; and the use of self-aligning roller bearings to compensate for misalignment of support.

Two Typical SMALLER DIAMETER *Units*...

Left—a Pillow Block designed for 12.00" diameter shaft. This illustrates one arrangement for automatic flood oiling from built-in oil reservoir.



Left—a Messinger Pillow Block, with self-aligning radial roller bearing, for 5.50" diameter shaft.

* * * *

Note the extreme compactness in over-all height. Both of the above units can be designed for shafts of any diameter.

Bearings may be radial or combination radial and thrust, to handle any type of loading.
If available space is a problem, consultation with a Messinger engineer-representative may be helpful.

MESSINGER BEARINGS, Inc.

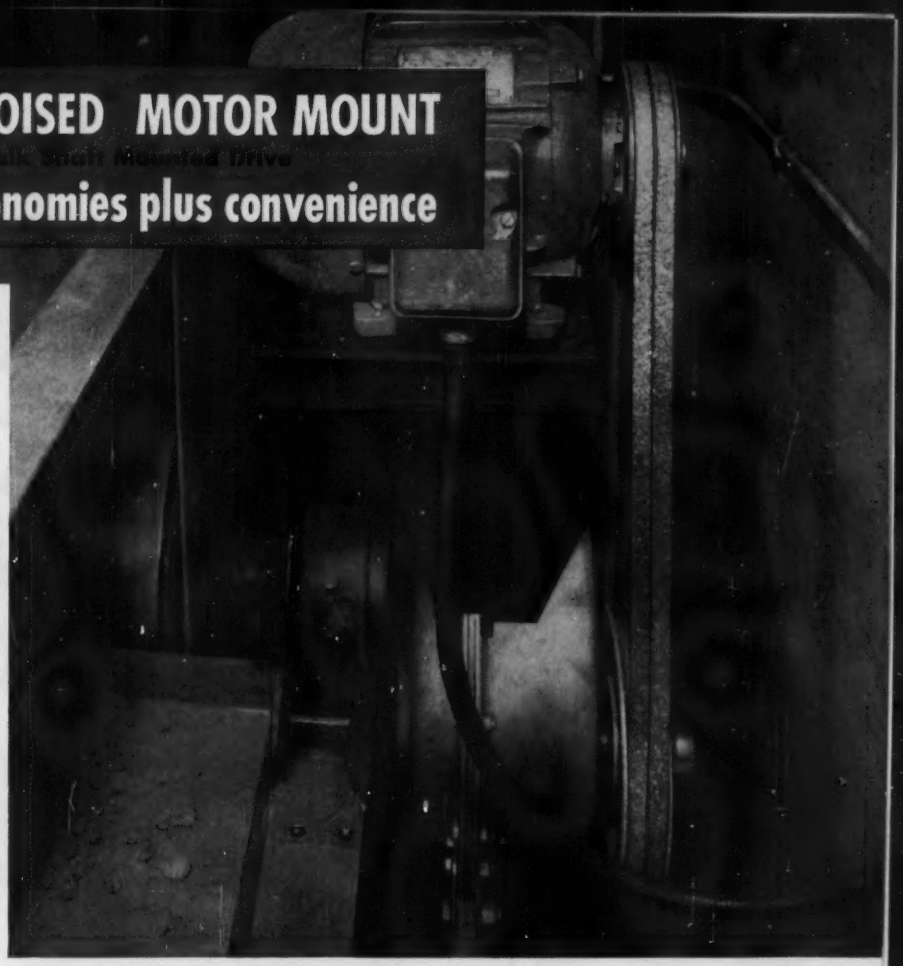
ROLLER AND BALL BEARINGS — *FEATHERWEIGHT TO HEAVYWEIGHT*

D STREET ABOVE ERIE AVE. • PHILADELPHIA 24, PA.

"Smoothing Industry's Pathway for Nearly Half a Century"

NEW FALK EQUI-POISED MOTOR MOUNT

gives unequaled economies plus convenience

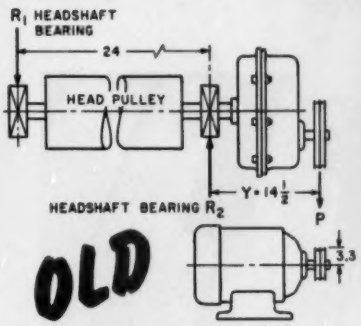


HOW A FALK EQUI-POISED MOTOR MOUNT REDUCES BEARING LOADS ON A DRIVEN MACHINE

GIVEN: Motor—15 hp, 1750 rpm, Frame 284U, Weight—320 lb.
Sheave diameters—6.6/9.4
Driven machine—belt conveyor with 24" center distance between headshaft bearings.

NOTE: Weights of 307J24 Shaft Mounted Drive, sheaves, and V-belts are eliminated from calculations because they remain constant; do not affect the comparison.

WITHOUT FALK MOTOR MOUNT



Torque at motor shaft = $\frac{63{,}025 \times 15 \text{ hp}}{1750 \text{ rpm}}$ = 540 lb-in.

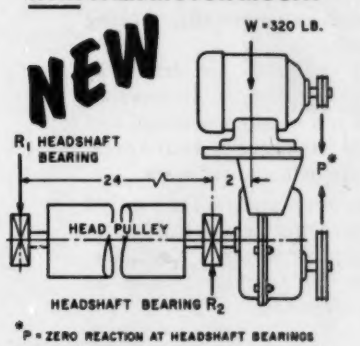
Belt pull (P) = $\frac{540 \text{ lb-in.}}{3.3''}$ x 1.5 Load Connection Factor
= 246 lb

$R_2 = \frac{246 \text{ lb} \times (24'' + 14.5'')}{24''}$ = 395 lb

$R_1 = \frac{246 \text{ lb} \times 14.5''}{24''}$ = 149 lb

(Check: 395 lb—149 lb=246 lb)

WITH FALK MOTOR MOUNT



*P = ZERO REACTION AT HEADSHAFT BEARINGS

V-belt pull has zero reaction on headshaft bearings. Therefore—

$R_2 = \frac{320 \text{ lb} \times (24'' + 2'')}{24''}$ = 347 lb

$R_1 = \frac{320 \text{ lb} \times 2''}{24''}$ = 27 lb

(Check: 347 lb—27 lb=320 lb)

Falk's new EQUI-POISED* Motor Mount is a rigid, all-steel weldment, pre-drilled for bolting standard NEMA foot-mounted motor (1/2 to 30 hp) directly to the steel frame of Falk Shaft Mounted, Flange Mounted and Screw Conveyor Drives. With it, motor can be mounted in almost any position around perimeter of reducer.

(*Balancing of forces.)

Substantial Savings for You

It saves engineering time required to design special motor bases and foundations...saves cost of labor and materials required to build special motor foundations...and saves on equipment costs by using a quality stock component. Further, its quick installation and easy maintenance mean added cost savings. The Motor Mount is a space saver, too. Where restricted space is a factor, ability to mount motor in any of several positions is an important convenience...For information on range of sizes, dimensions, etc., contact your Falk Representative or Distributor—or write direct for Bulletin 7100.

THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN

MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

FALK

a good name in industry

Representatives and Distributors in most principal cities

FALK is a registered trademark

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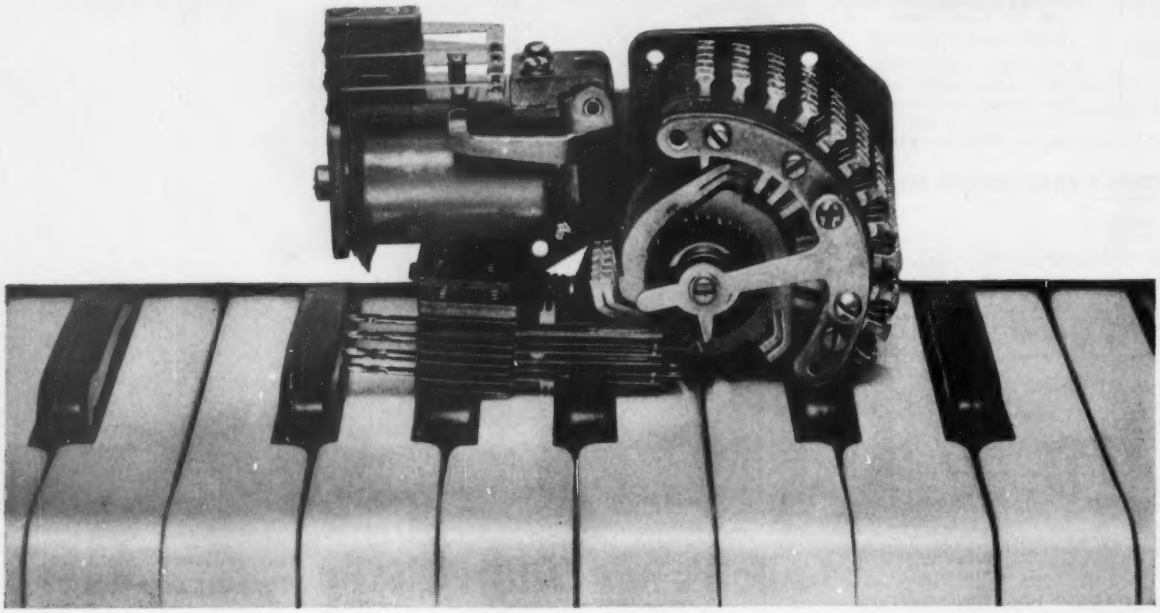
AE



To the Engineer

looking for a small-scale switch to do a large-scale job

If you have to perform complex switching maneuvers, fast, and in small space, you'll go for AE's Type 44 Rotary Stepping Switch.

This mere handful of rugged switching accommodates up to six bank levels, with 10 points plus home—will do the work normally assigned to whole banks of relays.

The miniature Type 44, and its big brother, Type 45, are the only stepping switches with a positive-action, free-floating pawl. This unique design eliminates armature-stop and pawl-stop readjustment – prevents pawl wear-and-tear, breakage, and binding. The pawl locking teeth position the rotor automatically, making overthrow impossible.

Incidentally, AE engineers are artists at composing simple circuits to do complex things – and AE can supply assembled and prewired control packages to your specs. Either way, we can help you cut costs.

For answers to *your* automatic control problems, write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1698-H on Rotary Stepping Switches.

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

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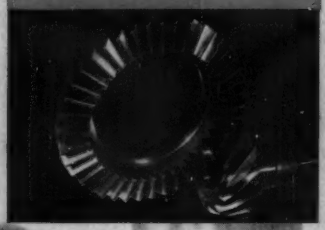
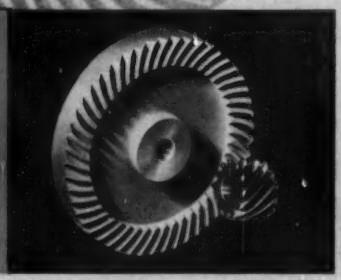
PLANOID® GEARS are low-ratio gears competitive with bevel and hypoid gears in efficiency and performance, but are manufactured at lower cost.



From Illinois Tool Works' unique family of gears . . .

new gear economies
with new gear efficiencies

HELICON® GEARS bring even greater production economy to high quantity applications than is possible with face, bevel or worm gears.



Shown here are typical examples of outstanding developments in right-angle gearing introduced by Illinois Tool Works. Pictured above is a Spiroid gear, the first major advancement in gearing in thirty years.

Spiroid® Gears do the same job as worm gears with this notable exception: they do it more economically and more efficiently in less space. They are recommended for application in the field of medium to high-ratio right-angle gearing. For maximum economy they may be sintered, molded or cast in metal or plastic; however, even hardened steel Spiroid gears for maximum power transmission are manufactured more cheaply than worm gears.

SEND TODAY FOR THESE NEW GEAR BOOKLETS Free booklets are available giving complete information on the design, manufacture, applications and advantages of each of these gears. Request your copies today.

Spiroid® gears

SPIROID DIVISION OF ILLINOIS TOOL WORKS

2501 North Keeler Avenue, Chicago 39, Illinois

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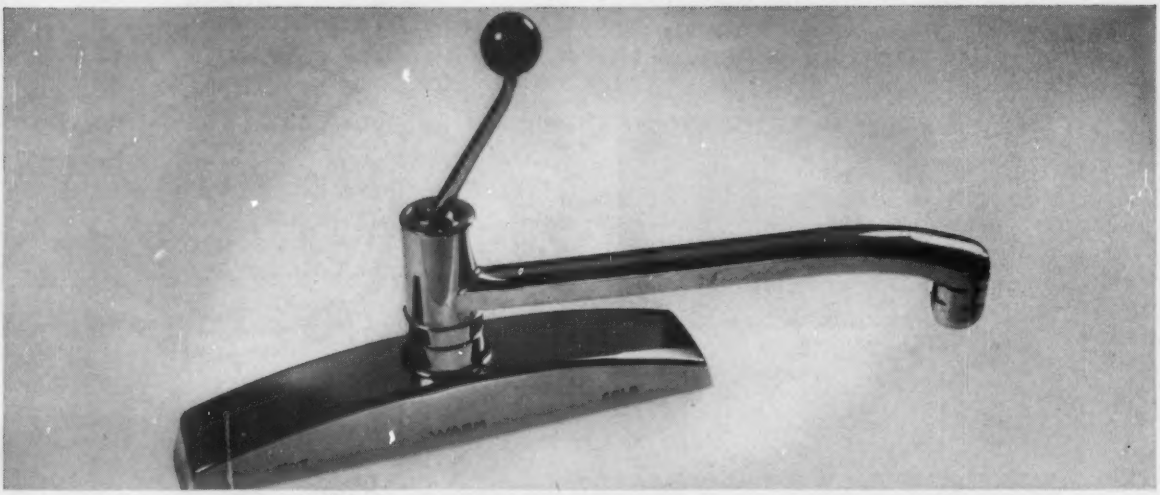
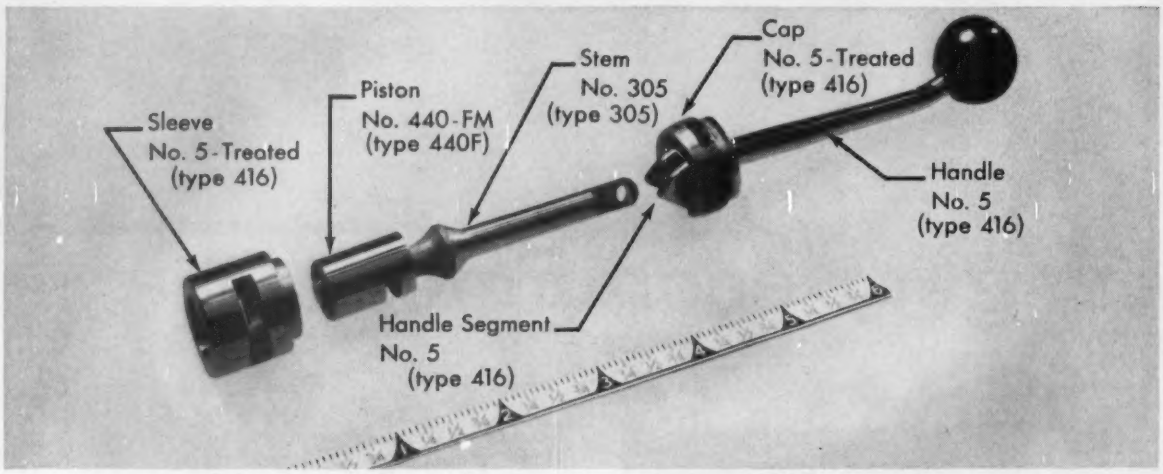


for strength, corrosion resistance and sales appeal

...it had to be Stainless

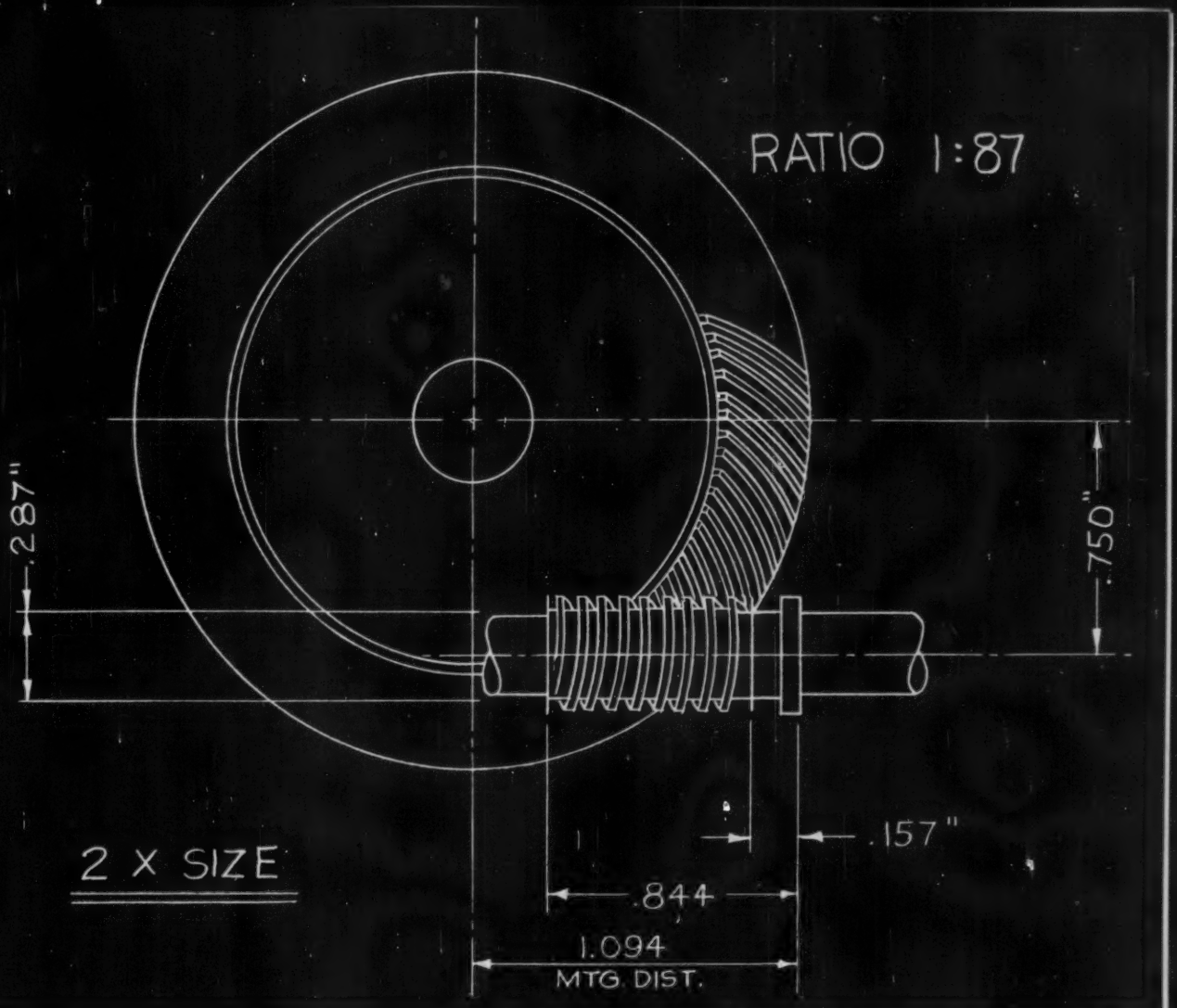


In this new one-handle mixing faucet all the important working parts are made of wear-resistant, corrosion-proof Carpenter stainless steels. Once you select stainless steel by Carpenter, you can forget about corrosion. You can design for high stresses, disregard maintenance problems, stop worrying about temperature variations and be assured that fabrication will be easy. And you not only get the help of consumer-acceptance of stainless products, but also the long experience of Carpenter. From the lab work through final production, Carpenter staffmen have the knowledge and the data. Call your Carpenter representative for the engineering information on stainless that you need. The Carpenter Steel Company, Reading, Pa.

Carpenter steel

Steel

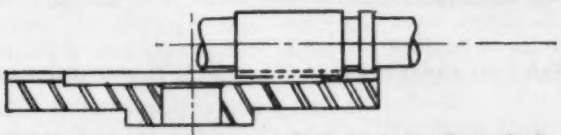
The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.
Webb Wire Division, New Brunswick, N. J.



HERE'S ANOTHER GEAR GLEASON BUILT FROM FIRST DESIGN TO FINAL PRODUCT

This is the finished prototype of a new high-ratio hypoid gear. Our customer will now produce it, royalty free, on his Gleason equipment.

This is but one example of what Gleason engineering service can do for people who need gears. Our facilities and advice are at your constant disposal for development of bevel and hypoid gears to meet the needs of any application.



This particular high-ratio pair (actual size shown in insert) offers several advantages over conventional gears:

GREATER STRENGTH. High-ratio hypoid pinions are larger and stronger than corresponding bevel pinions.

COMPACTNESS. Where space is a problem, the high-offset principle lets you design a more compact and flexible unit than the corresponding worm and wheel.

SMOOTHER ACTION. High-offset pairs provide smooth, quiet tooth action . . . *continuous* action even with only one or two teeth, because of the way the teeth wrap around the pinion.

STRADDLE MOUNTINGS. Cylindrical high-ratio pinions, with extended shank, make practical very rigid straddle mountings.

GRINDING. High reduction hypoids are cut on same Gleason equipment used on familiar bevel and hypoid gears. Same testers, quenchers and other auxiliary equipment can be used. Grinders are available for the ultimate in precision and finish to minimize friction.

LET GLEASON MAKE RECOMMENDATIONS. Send along a set of prints, and we'll be glad to study them and give you our thoughts on how best to make the gears you need.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

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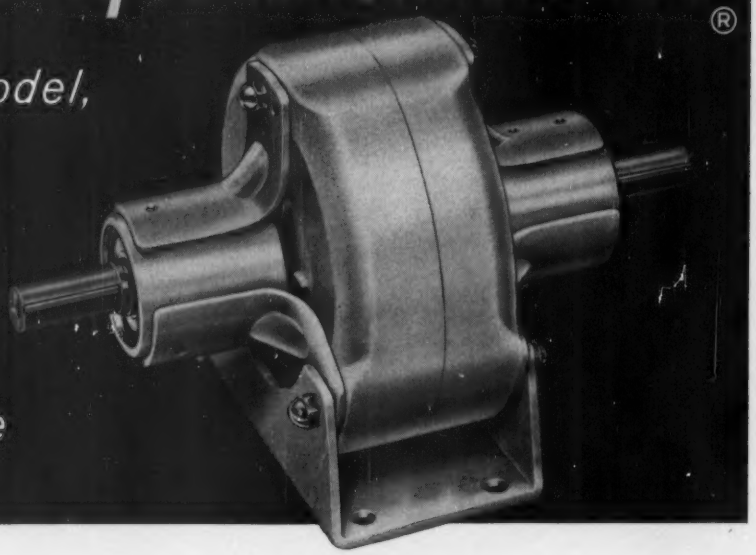
VICKERS SLASHES PRICE 1/3 ON NEW 10 lb./ft. MAGNECLUTCH®

a great new model, substantially improved in reliability and service life



Skilful design and engineering have slashed the cost and weight of this new clutch one-third below that of the older 10 lb.-ft. model, at the same time increasing its efficiency and service life. Unexcelled performance characteristics are identical with the other MAGNECLUTCHES in the Vickers line:

- No wear on torque transmitting surfaces
- Smooth operation, without grab or chatter
- Full torque at zero slip, transmitted with 100% efficiency
- Torque independent of speed
- Fast response
- Close control of torque through the entire operating range

The new MAGNECLUTCH* has been laboratory tested for more than 10,000,000 on-off cycles, performing surely and dependably all the way. It's a great new addition to the Vickers MAGNECLUTCH line, which includes air cooled and water cooled models up to 200 lb.-ft. capacity.

*Dry Magnetic Particle Clutch

EPA 6100-4

For complete data, write for NEW BULLETIN 6106-5. Watch for announcement of new 5 lb.-ft. MAGNECLUTCH

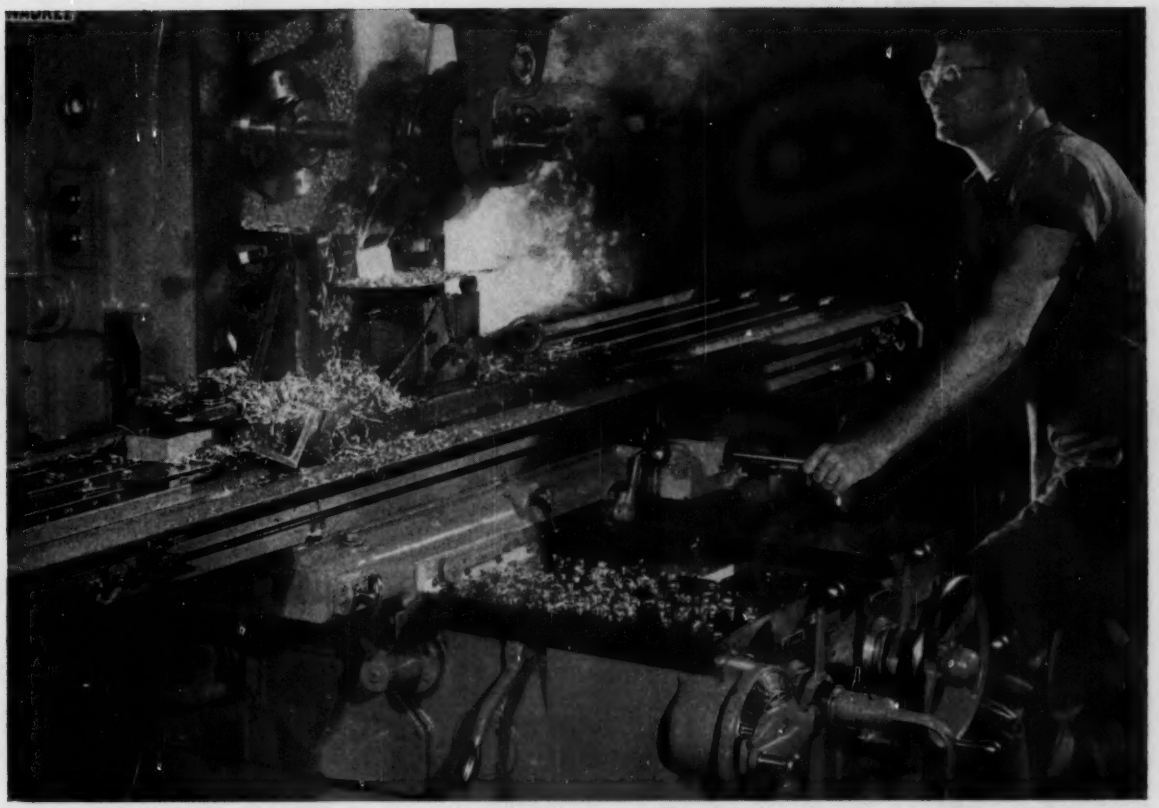
VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

ELECTRIC PRODUCTS DIVISION

1881 LOCUST STREET / SAINT LOUIS 3, MISSOURI

Sales Engineering Offices: BOSTON (Rep.)—CEdar 5-6815 • CHICAGO—JUniper 8-2125 • CHICAGO (Distr.)—FRanklin 2-7272 CLEVELAND—EDison 3-1355 • DALLAS (Rep.)—EMerson 8-4655 • DENVER (Rep.)—MAin 3-7201 • DETROIT—TOwnsend 8-5100 • DETROIT (Distr.)—TRinity 4-1010 • GREENVILLE (Rep.)—CEdar 2-2421 • LOS ANGELES—DAvenport 6-8550 • LOS ANGELES (Distr.)—MUtual 3144 MILWAUKEE (Distr.)—ORchard 2-9220 • NEW YORK CITY—LEnox 9-1515 • PITTSBURGH (Rep.)—ATlantic 1-4692 • SAN FRANCISCO (Rep.)—JUniper 6-1860 • WASHINGTON, D. C.—EXecutive 3-2650



As this heavy-duty milling machine makes a high-speed cut, vital components of AISI 4340 and 4620 nickel alloy steels provide strength and wear-resistance, help maintain precision tolerances.

Two nickel alloy steels...4340 and 4620... give this machine sustained cutting accuracy

Here's how two general-purpose steels used by Kearney & Trecker in their heavy duty TF series milling machine have helped that company maintain its famous high-performance standards:

The spindle is made of AISI 4340 nickel alloy steel. This through-hardening steel is quenched and tempered to develop good fatigue strength and high tensile strength with a minimum of distortion. Spindles of 4340 steel resist torsional stresses and wear while maintaining straightness at every running speed.

Gears are precision-cut and wide-faced. They are made of AISI 4620 general-purpose carburizing steel. These gears are carburized and hardened to 58-62 Rockwell "C". What's more, AISI 4620 nickel alloy steel has a tough core to withstand shock loading.

This report is typical of the many coming in from manufacturers who have employed the two General Purpose Steels for a variety of machinery components.

Available right off the shelf from your local Steel Service Center, AISI 4340 and 4620 offer you a two-fisted way to cut costs and still satisfy the majority of your engineering requirements. Other standard nickel-containing steels – providing particular combinations of properties – are also available from your Steel Service Center for your remaining needs.

Consider nickel alloy steels for gears, shafts, bearings and other machine parts you design, order or use. And any time you require engineering information to help you select the right material for your application, write to INCO, outlining your problem. We will be glad to help.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

INCO NICKEL

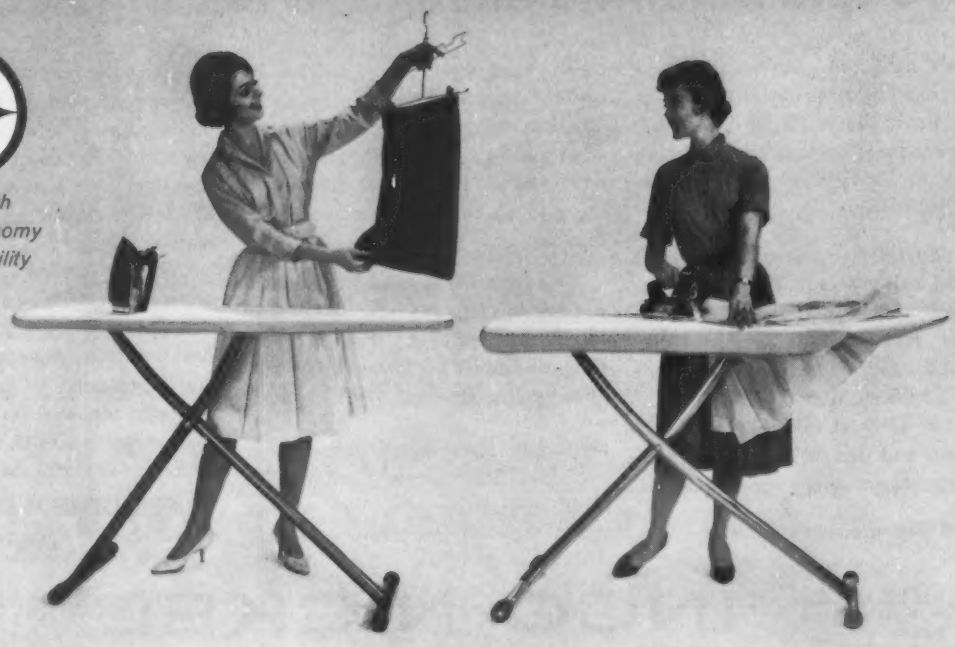
NICKEL MAKES ALLOYS PERFORM BETTER LONGER

Circle 466 on Page 19→

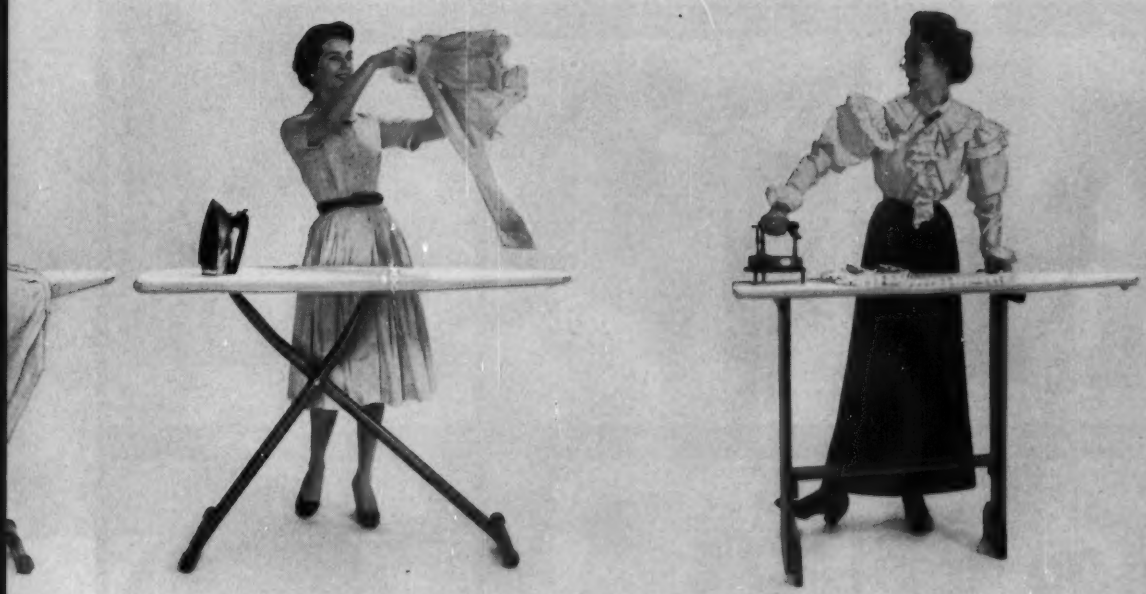
Now 6 out of 7

Steel

For strength
. . . economy
. . . versatility



ironing "boards" are made of sheet steel



Just fifteen years ago, all but 15 per cent of ironing boards were made of wood. Today, it's the other way around: 6 out of 7 are made of strong, durable, inexpensive sheet steel, with features that could never be achieved with wood.

The "Mary Proctor Hi-Low Ironing Table" shown here is a good example. Its steel top is pleated for extra strength, with steam vents that channel heat away from the ironer's lap for cooler ironing. Sturdy tubular legs rolled from sheet steel are light in weight yet provide solid support.

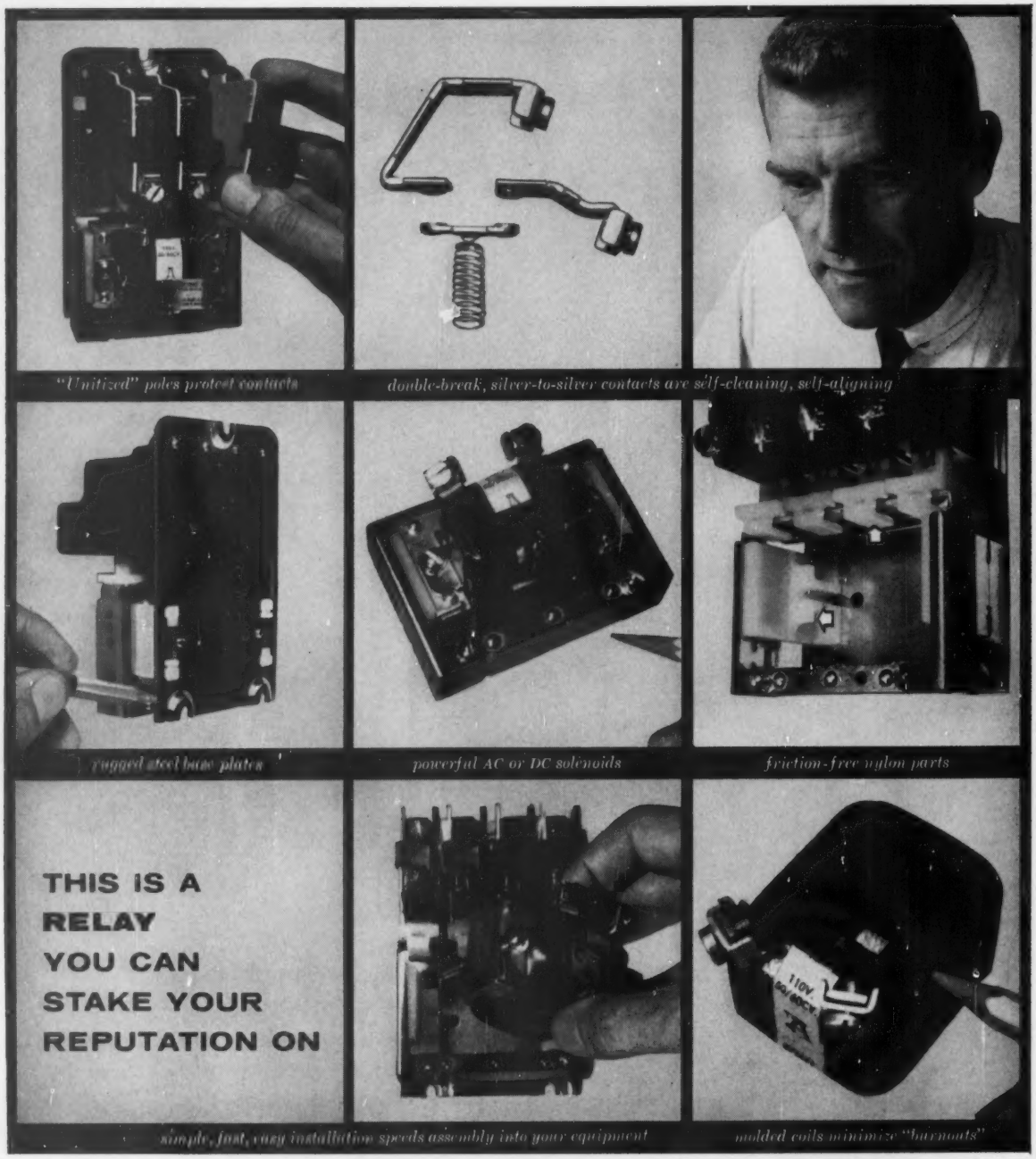
Bethlehem furnishes large tonnages of cold-rolled steel to the Proctor-Silex Corporation, makers of the "Mary Proctor Hi-Low Ironing Table."

If you work with steel sheets—hot-rolled, cold-rolled, or galvanized—you can always count on Bethlehem sheets for completely dependable performance. Our engineers will be glad to discuss your sheet-steelworking problems with you.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



every aspect of Ward Leonard bulletin "HR" relays is designed for maximum reliability . . . these are components you can buy, install and then forget

Ward Leonard "HR" relays are engineered for industrial and electronic applications requiring: ultra-long life, high speed, high reliability, compactness and versatility.

Consider the powerful solenoids, just one of the features shown above. Every HR relay, AC or DC, is equipped with a powerful solenoid to assure fast, consistent, long-life operation so essential in the circuitry of any high reliability relay. The "E-I" laminated magnet armature is free-floating and self-aligning to minimize noise level. DC solenoids feature exceptionally fast operation. Nylon armature guides minimize operational friction. All AC and DC power plants are readily interchangeable.

2 to 8 pole "HR" relays are but one of five W/L lines of industrial power relays . . . all designed with emphasis on reliability. Write for bulletin 4470. Ward Leonard Electric Co., 58 South Street, Mount Vernon, N.Y. ⊙-1

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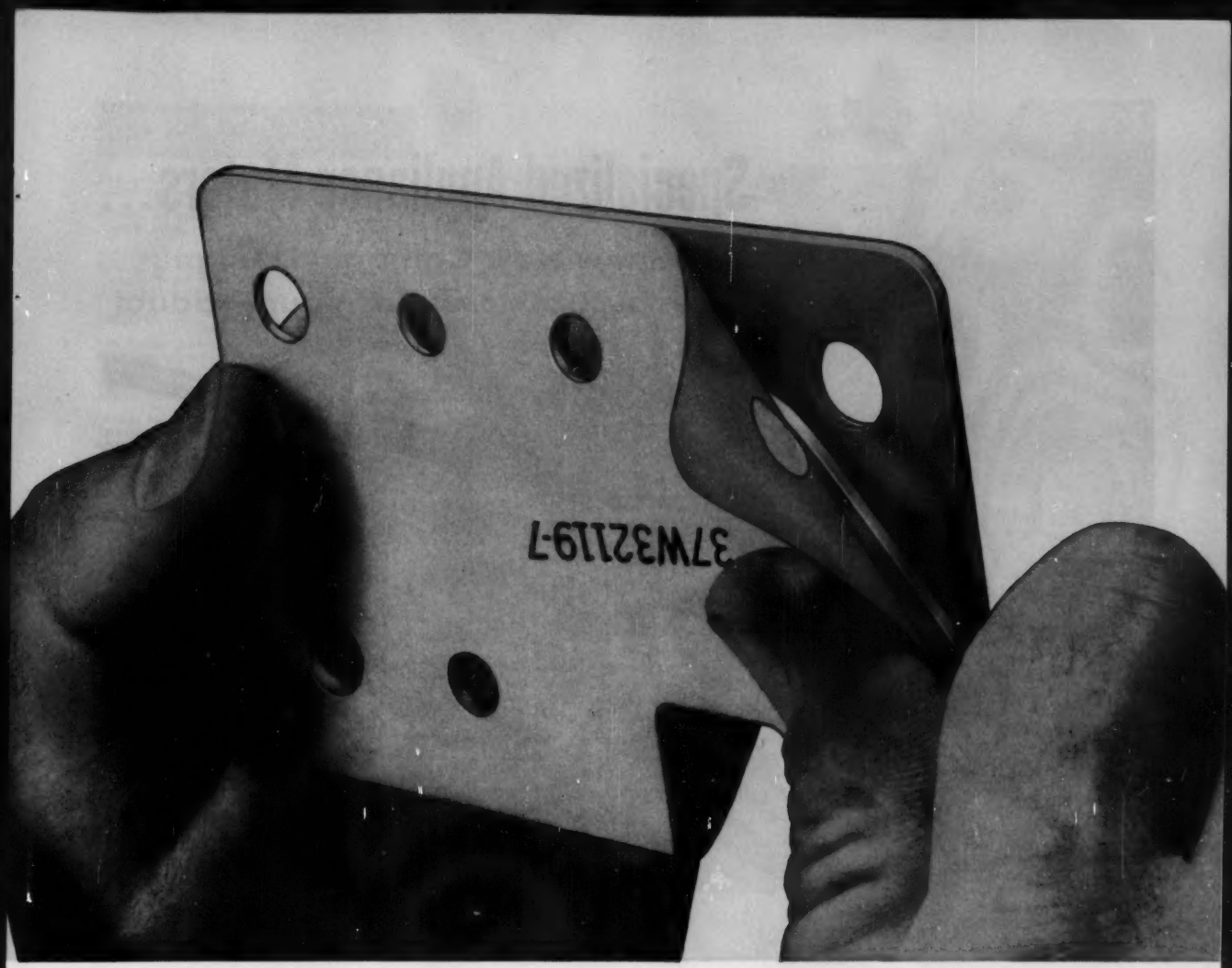
ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

LIVE BETTER...*Electrically*

Basic-Engineered Controls Since 1892

RESISTORS | RHEOSTATS | RELAYS | CONTROLS | DIMMERS

Circle 467 on Page 19



Simplest, surest way to a "thousandth" fit . . . right at the job

What you see here is a shim. Not an ordinary shim, but a shim of LAMINUM—and that's what makes the difference in convenience, accuracy, speed and economy.

LAMINUM is the registered trade name for the laminated shims whose layers are completely surface-bonded to look and act like solid metal. Yet the laminations are easily p-e-e-l-e-d to bring the shim to any desired thickness for an individual, perfect fit, right at the assembly line.

No stand-by equipment. No machining. No grinding. No counting. No stacking or miking. And no grit between layers —ever. *That's* what saves time! And cuts costs!

Shims of LAMINUM are economically custom-made to your specifications. In brass, mild steel, stainless and aluminum, with laminations of .002″ or .003″. For quick service, send your inquiries for information or estimates directly to . . .

THE LAMINATED SHIM COMPANY, INC.

Home Office and Plant 1207 Union Street, Glenbrook, Connecticut
West Coast Sales and Service: 600 Sixteenth St., Oakland 12, Calif.

Circle 468 on Page 19

GET THE FACTS

Write for SHIM DESIGN Folder No. 3—eight pages of up-to-date, well illustrated design information and specifications.

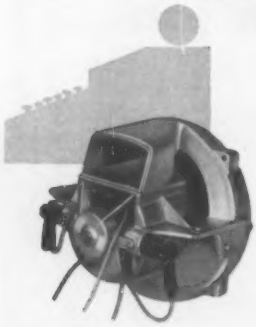
Specialized Appliance Motors...

Show How Compact Design Can be Obtained For Your Product

Single-stage worm gearmotor. Rolled thread on output shaft actuates traveling nut.

Parts for double-shaft floor polisher. Shaft has two rolled worms, right and left hand.

Nozzle agitator motor for use with canister-type vacuum cleaners. (Single coil field)



Custom-built motor and fan assembly for upright domestic vacuum cleaners.

Skeleton frame motor for vegetable juicer.

For devices — vacuum cleaners, floor polishers, food mixers and the like — where it is important to obtain a compact, light-weight design, streamlined styling and favorable cost, a Lamb® specialized appliance motor will provide optimum results.

May we demonstrate these advantages of Lamb motors for your new or redesigned products? Descriptive folder sent on request.

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SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Divisions of American Machine and Metals, Inc., New York 7, New York TROY LAUNDRY MACHINERY
RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS
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ARIZONA
Phoenix: Air-Draulics Co. AL 4-4703
Phoenix: Arrow Valve Corp. AL 4-7294
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Jacksonville: Dixie Bearings, Inc. EL 5-1387
Miami Springs: Wencor, Inc. NE 5-0700
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Hapeville: Air Associates, Inc. PO 6-5353
Atlanta: Dixie Bearings, Inc. JA 4-5601
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Chicago 22: W. H. Salisbury Co. HA 1-4850
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Indianapolis: Avels Sales & Eng. Co. ME 9-1326
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Cedar Rapids: Globe Mach. & Supply EM 5-6911
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Baltimore: Louis H. Hein Co. MU 5-5654
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Kalamazoo: Depatie Fluid Power FI 4-1830
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Cleveland: Cleveland Ball Bearing Co. HE 1-8866
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Portland: Bearing Sales & Service CA 6-7141
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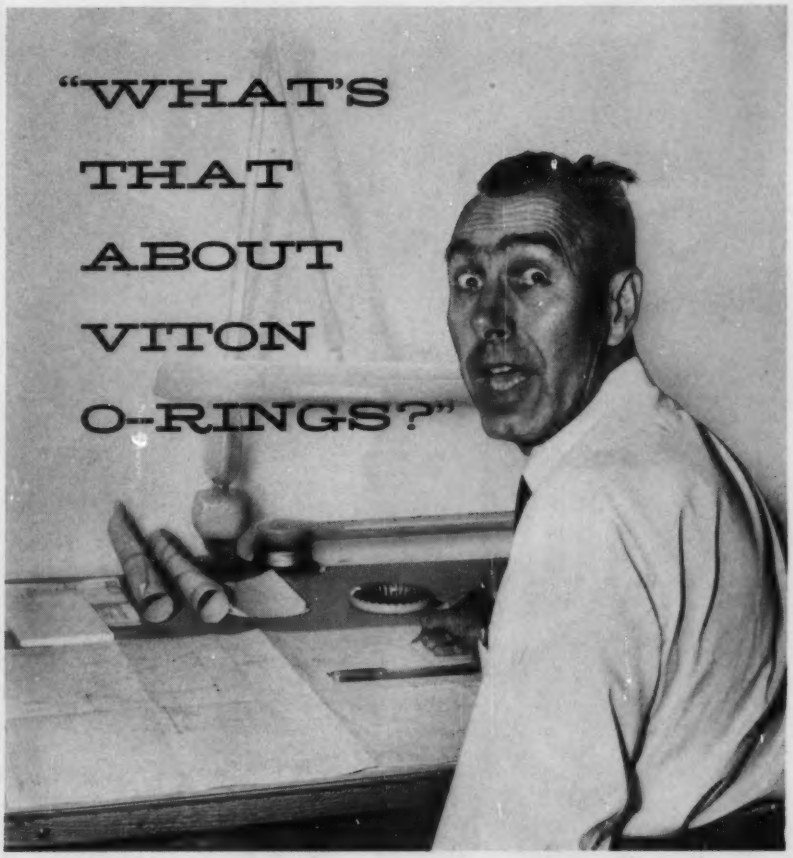


"Well, sir, it's this —

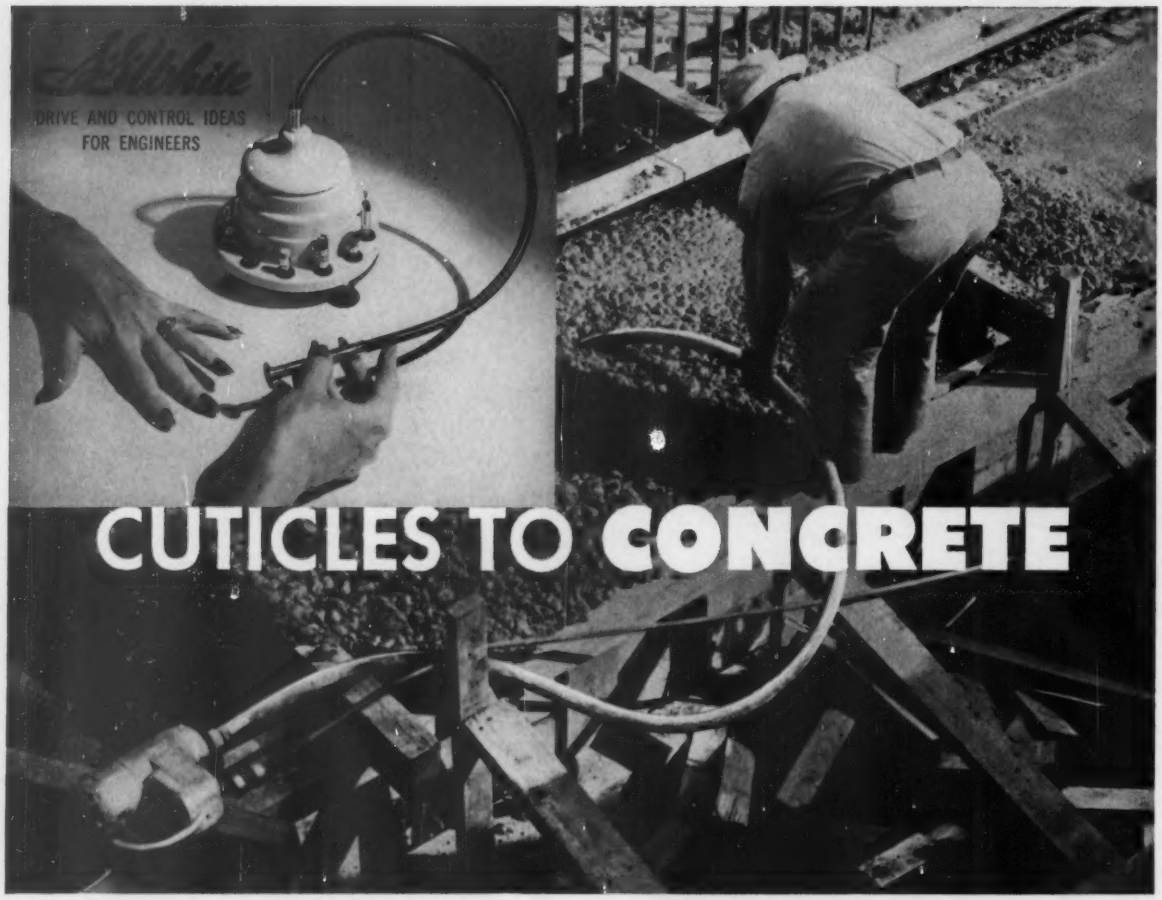
"Parker Seal Company has pioneered in research, developing and engineering Viton O-Rings. This responsible leadership in O-Ring engineering enables them to offer these firsts in Viton:

1. All AN (ARP) sizes as *standards* — no charge for tooling, faster delivery, *proved* and *tested* quality.
2. Industrial Viton O-Rings at amazingly low cost.
3. A Viton Design Handbook with considerable basic material on design, compounds and sizes.
4. Little or no lead time, even on "exotic" compounds developed for special applications."

Parker Seal Company's nation-wide staff of sales engineers and distributors are eager to serve you. If you would like a copy of our Viton O-Ring Handbook call the distributor nearest you (see list at left) or write direct to factory.

Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio
A DIVISION OF PARKER-HANNIFIN CORPORATION

Circle 470 on Page 19



Flexible shafts carry torque to spare...

Whether your product requires delicacy or raw strength, there's a flexible shaft available from S. S. White to transmit rotary power or control.

For example, the .043″ dia. flexible shaft in the manicurist's tool transmits approximately 0.38 pound-inches at high speed and provides extreme flexibility of operation – suitable to M'Lady's finger-tips. Or, consider the Viber Concrete vibrator which needs a .437″ dia. shaft, capable of transmitting high torque at 10,000 rpm under brutal field conditions.

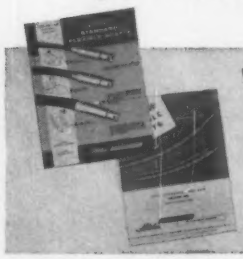
Keep flexible shafts in mind for applications other than power tools, too. They allow the designer important – sometimes vital – latitude in positioning both power source and driven part... freedom to snake power around obstacles, freedom to obtain balance and structural economy.

Flexible shafts solve a lot of other problems too. They help you to eliminate parts... expensive, cumbersome gears, drives, universals. Make installation easier because they have no alignment problems. Machine performs better too, because vibration, shock, overloads are absorbed by rugged flexible shafts.

Whatever your problems, look into S. S. White's three lines of flexible shafts: Standard ...Pre-Engineered...Custom-Designed. There's bound to be an answer for you.

S. S. White Industrial Division, Dept. 4
10 East 40th Street, New York 16, N. Y.

1121



WRITE FOR COMPLETE DATA

Standard S. S. White flexible shafts are available "off the shelf," making many savings possible. **Write for bulletin 5601.**

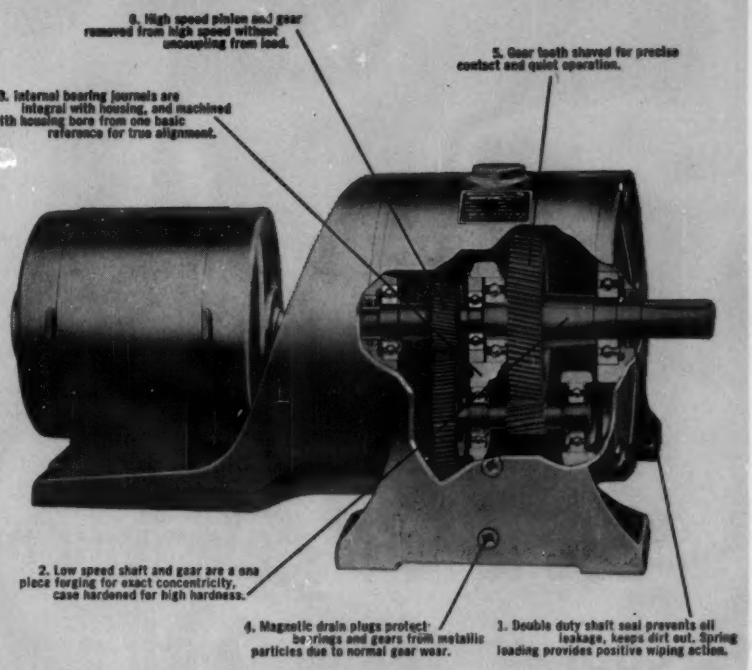
S. S. White also offers engineering service and comprehensive selection of flexible shaft sizes and types to meet special requirements. **Write for bulletin 5601.**

S.S.White®
FIRST NAME
IN FLEXIBLE SHAFTS

on the long run...

QUALITY COSTS YOU LESS!

And some of the features illustrated here tell why. Accurate tooth loading through precise gearing, freedom from distortion under load and accessibility from either end are a few of the reasons why the Western Gear StraitLine Gearmotor is considered a standard of quality wherever it goes. Your nearby Western Gear sales engineer is ready to supply you with additional information for your next application. And for a starter, use the coupon in this ad to get our basic bulletin No. 5806-F.


6. High speed pinion and gear removed from high speed without uncoupling from load.
5. Gear tooth shaved for precise contact and quiet operation.
3. Internal bearing journals are integral with housing, and machined with housing bore from one basic reference for true alignment.
2. Low speed shaft and gear are a one piece forging for exact concentricity, case hardened for high hardness.
4. Magnetic drain plugs protect bearings and gears from metallic particles due to normal gear wear.
1. Double duty shaft seal prevents oil leakage, keeps dirt out. Spring loading provides positive wiping action.

MAINTAIN HIGH PRODUCTION WITH
THE WESTERN GEAR FAMILY OF
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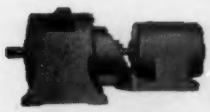
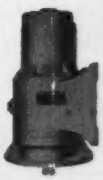
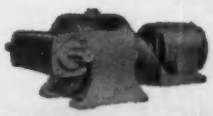


SHOVEL-BASE GEARMOTOR

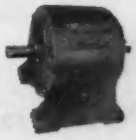


VERTICAL GEARMOTOR

INTEGRAL GEARMOTOR



SHOVEL-BASE REDUCER WITH RIGHT ANGLE HEAD



STRAITLINE SPEED REDUCER

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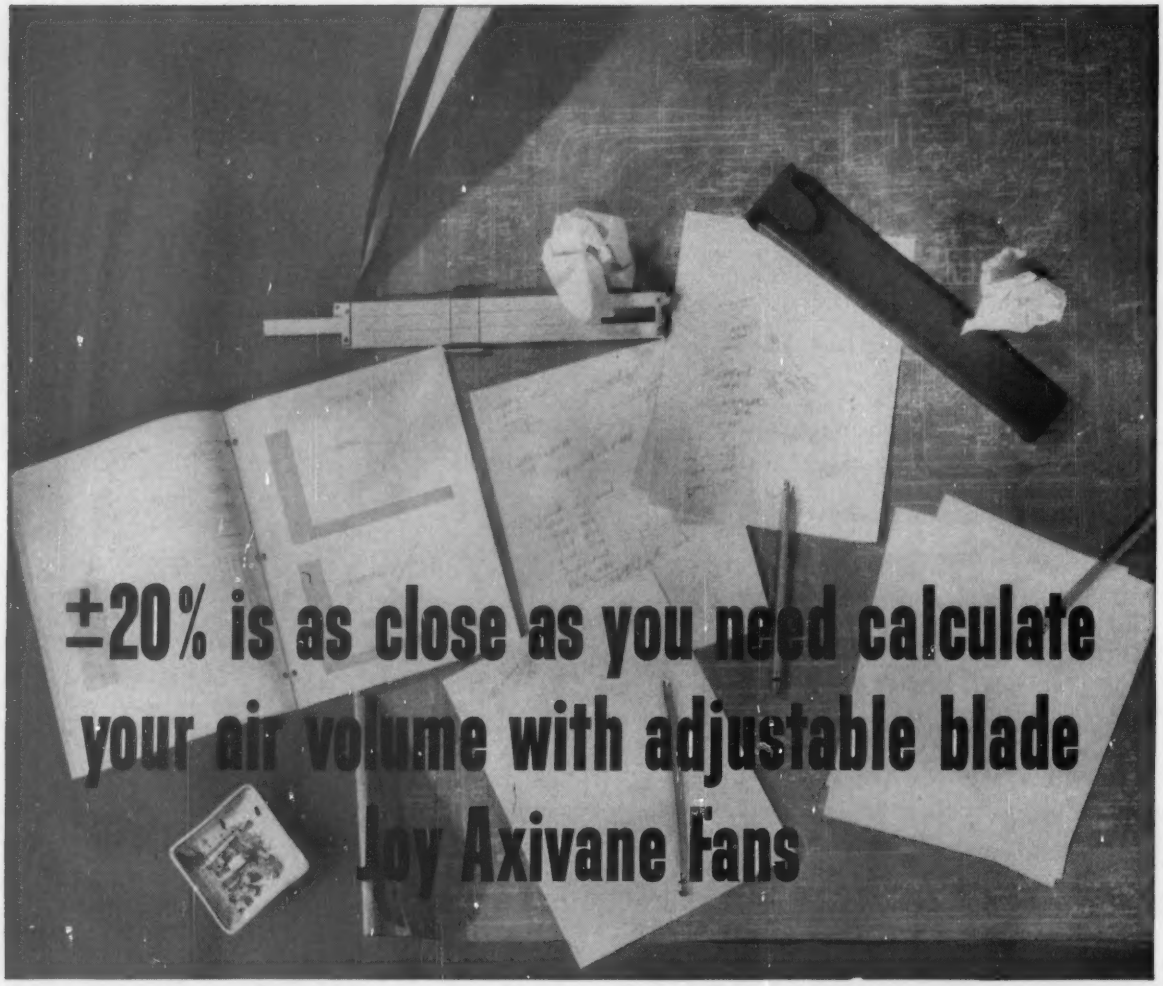
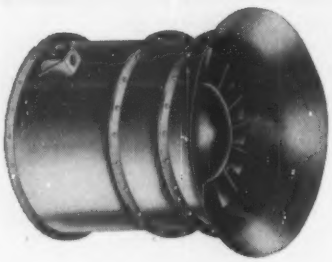




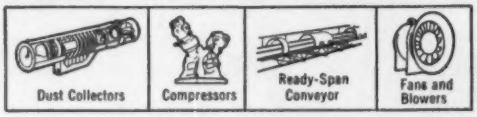
Ask for Bulletin 290-64B.

Computation of air volumes required for ventilation can be greatly simplified by installing Joy Axivane Fans. Standard models are furnished with adjustable blades which can be rotated to change pitch, and consequently volume, over a considerable range. This permits compensating for circumstances unforeseen when air requirements were computed, and also allows the installation of fans which will be able to efficiently supply additional air for pre-planned expansions of the plant. Blade adjustments can be made by anyone in a matter of minutes. Calibrated scales on hub and blades assure accurate matching of blade pitches.

Joy Axivane Fans are designed with integral motors to permit in-duct installation. This reduces installation costs, and saves space. The fans are available in a wide range of sizes for every type of duty, and can be furnished in special materials for use in corrosive atmospheres.

Whatever your fan requirements may be, Joy has the answer.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Circle 473 on Page 19

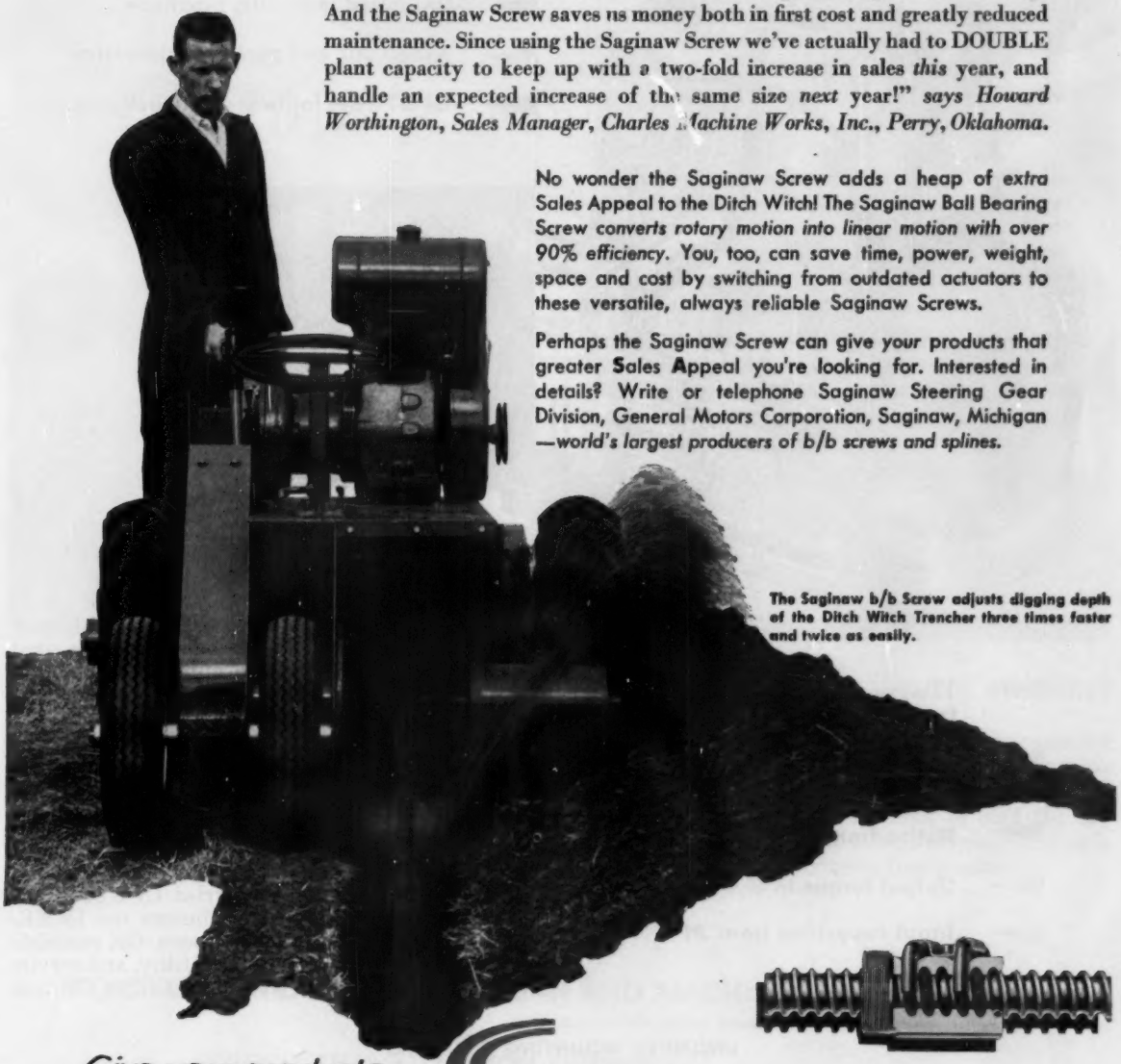
the SAGINAW b/b SCREW helps

Double Ditch Witch Sales in One Year!

"We've replaced an acme screw with a Saginaw Ball Bearing Screw to enable the digging boom of our Ditch Witch Trench Digging machine to be raised and lowered three times faster. It makes the operator's job twice as easy. And the Saginaw Screw saves us money both in first cost and greatly reduced maintenance. Since using the Saginaw Screw we've actually had to DOUBLE plant capacity to keep up with a two-fold increase in sales *this* year, and handle an expected increase of the same size *next* year!" *says Howard Worthington, Sales Manager, Charles Machine Works, Inc., Perry, Oklahoma.*

No wonder the Saginaw Screw adds a heap of *extra* Sales Appeal to the Ditch Witch! The Saginaw Ball Bearing Screw *converts rotary motion into linear motion with over 90% efficiency.* You, too, can save time, power, weight, space and cost by switching from outdated actuators to these versatile, always reliable Saginaw Screws.

Perhaps the Saginaw Screw can give *your* products that greater **S**ales **A**ppeal you're looking for. Interested in details? Write or telephone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan —*world's largest producers of b/b screws and splines.*



The Saginaw b/b Screw adjusts digging depth of the Ditch Witch Trencher three times faster and twice as easily.

Give your products NEW SALES APPEAL... switch to the **Saginaw** ball bearing **Screw**

WORLD'S MOST EFFICIENT ACTUATION DEVICE

FOOTE BROS. introduces a FAN-COOLED

- High load carrying capacity
- Super-efficient 2-way cooling for higher thermal ratings
- Unlimited mounting positions
- Automatic and positive lubrication
- IN STOCK for immediate delivery

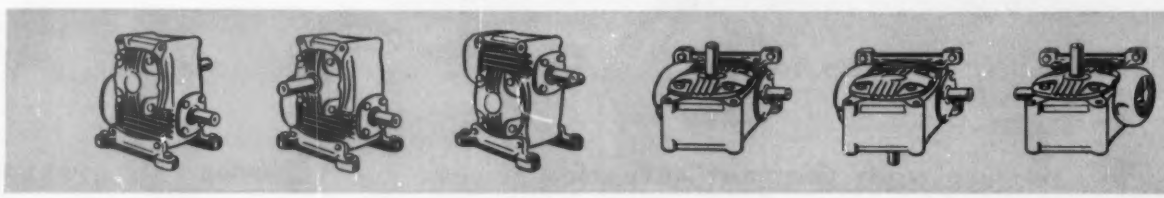
- 12 sizes—Center Distances from 1⅛" to 8"
- Rated to NEW AGMA Standards
- Ratios from 5:1 to 70:1
- Output torque to 46,000 lb. in.
- Input capacities from .01 to 66 HP

Foote Bros. RADICON Worm Gear Reducers incorporate *totally new* concepts of speed reducer design and construction. From the inside out and top to bottom, they embody years ahead thinking to provide users with more efficient, more versatile right angle power transmission in minimum size units.

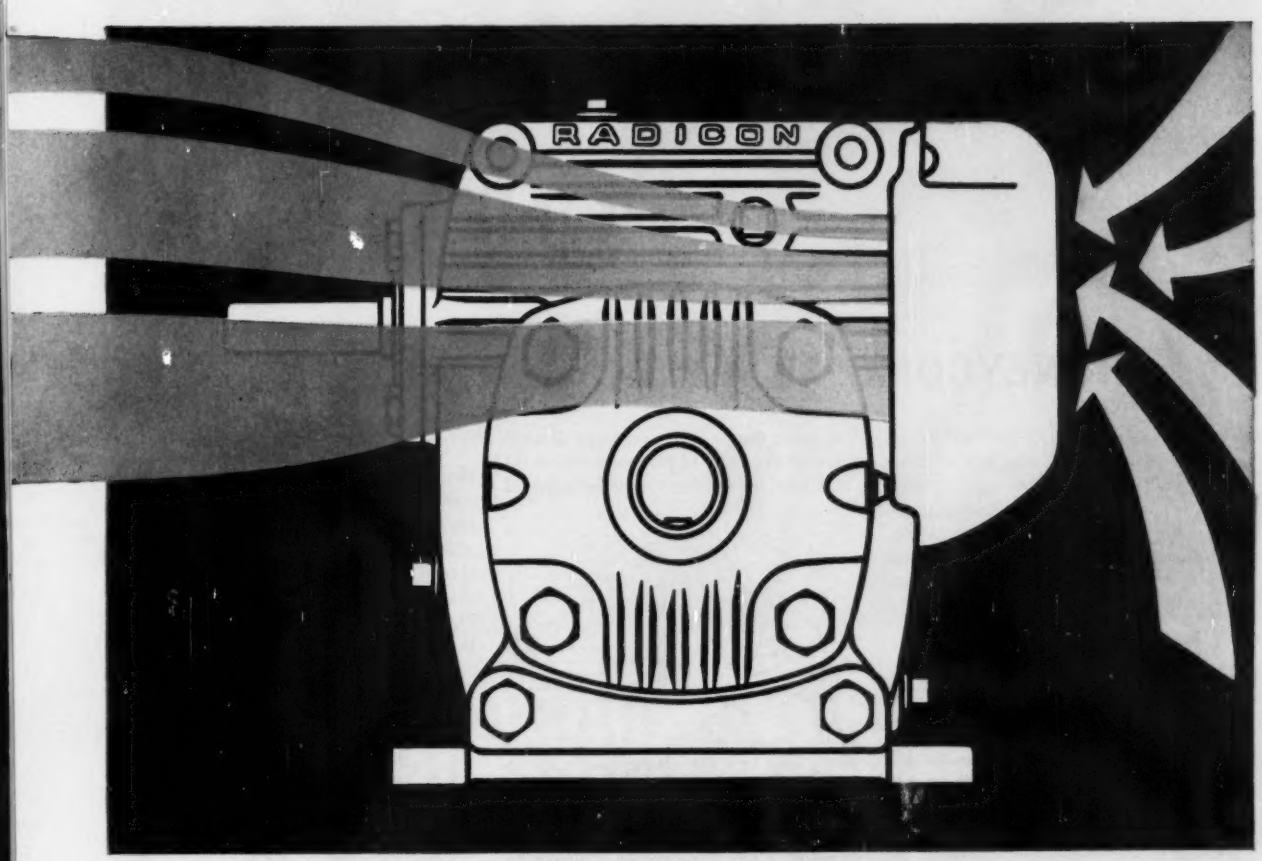
Gear accuracy and surface finish, bearing and shaft design, positive lubrication, extreme efficiency controlled cooling, the selection of materials and precision manufacturing techniques—all reflect careful attention to detail that results in higher load carrying capacity and maximum service life.

These outstanding new fan-cooled worm gear reducers are available now—carried IN STOCK by Authorized Foote Bros. Distributors for IMMEDIATE DELIVERY. See them soon. Get complete details on the performance, versatility, and service life they will bring you. Write for RADICON Catalog.

UNLIMITED MOUNTING POSITIONS



COMPLETELY NEW and ADVANCED line of WORM GEAR REDUCERS



RADICON Reducers operate in a STREAM OF AIR for maximum thermal efficiency

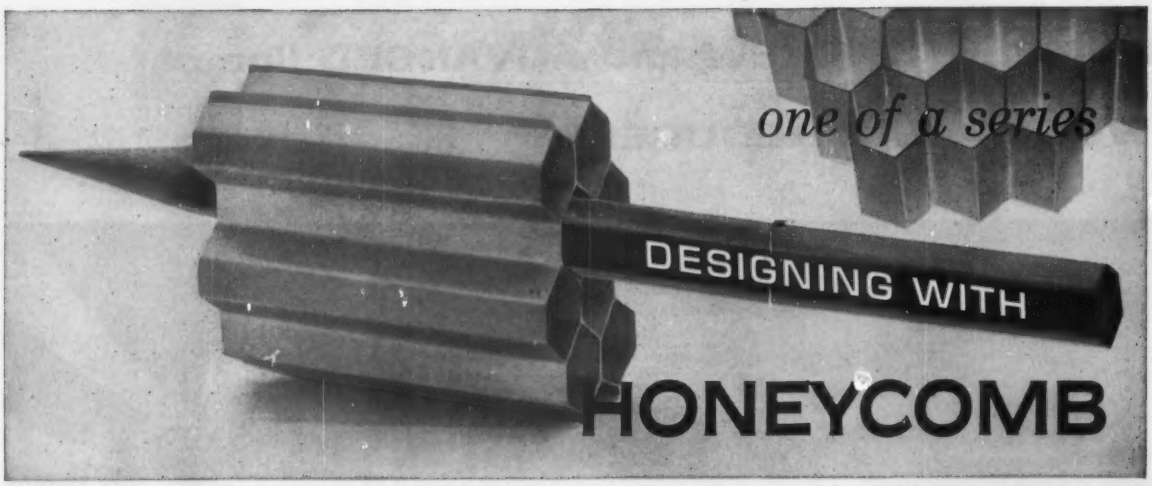
Advanced design of RADICON Worm Gear Reducers and their high efficiency radiation and convection cooling for controlled transfer of heat to the outside air, permit *identical* thermal and mechanical ratings in most cases. For infrequent or intermittent service, thermal ratings can be ignored.

A moving stream of air, induced by the maximum diameter fan, forcing high velocity cooling air along horizontal channels formed by the external ribbing, dissipates radiated heat to hold the Reducer's temperature rise to a minimum. Cooling is equally efficient at any mounting position.

FOOTE BROS. GEAR AND MACHINE CORPORATION

4567 South Western Boulevard, Chicago 9, Illinois

POWER TRANSMISSION DRIVES



#7 HONEYCOMB AS A FLOW CONTROLLER

The clean edges and parallel cell orientation of expanded honeycomb offer new solutions to the problem of straightening, changing the direction of, or otherwise controlling the flow of air, other gases, and liquids. In general, directional characteristics of honeycomb have three separate uses: deflecting, directing and guarding (as in grilles and registers).

Air Deflection and Direction

When a stream of air is intercepted by a piece of honeycomb, the air is uniformly deflected into a direction parallel to the cell axes, and the direction of flow of the stream of air is controlled by the relative position of the honeycomb (Fig. 1). This unique property of honeycomb also permits its use

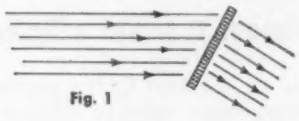
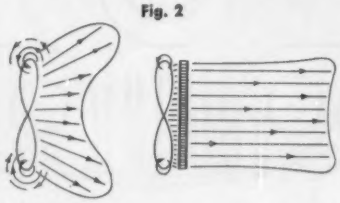



Fig. 1

as a flow straightener immediately downstream from a fan blade. Honeycomb almost entirely removes the turbulence created by the rotation of the fan and allows the air stream to maintain a much higher velocity than would otherwise be possible (Fig. 2).

The exact degree of improvement depends upon the proximity of the honeycomb to the fan blades, the amount of turbulence caused

Fig. 2



by the fan, and whether it is in open air or surrounded by a duct. Honeycomb's low resistence characteristic can be advantageously used to either raise flow rate with existing blowers by as much as 50% or, alternately, to reduce power requirements of blowers by an equivalent amount.

Fluid Direction

Straightening or directionalizing of flow is not restricted to fans operating in air; this property of honeycomb can also be applied to other gases and liquids. It has been found, for instance, that the addition of a honeycomb flow straightener immediately upstream from a liquid flow meter contributes to efficient and accurate operation of the meter at much higher flow rates. Honeycomb was chosen for this assignment because of its ability to straighten flow, plus the extremely low pressure drop resulting from its installation.

Grilles and Registers

Honeycomb's high percentage of open area makes it particularly suitable as a grille or register. Because honeycomb has a unique ability to attenuate radio frequency noise, several large electronic installations have successfully used honeycomb grilles in cooling air openings. In this type of application, the cell size and slice thickness are critical

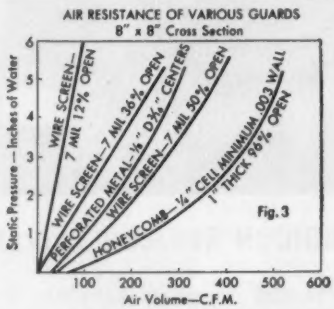

AIR RESISTANCE OF VARIOUS GUARDS
8" x 8" Cross Section
Static Pressure — Inches of Water
Air Volume—C.F.M.
WIRE SCREEN—7 MIL 12% OPEN
WIRE SCREEN—7 MIL 36% OPEN
PERFORATED METAL—⅛" D ⅜" CENTERS
WIRE SCREEN—7 MIL 50% OPEN
HONEYCOMB—¼" CELL MINIMUM .003 WALL 1" THICK 96% OPEN

Fig. 3

in determining the range of frequencies below which complete blocking occurs. Light transmission is also made possible when RF filters are fabricated from honeycomb.

In all of the applications mentioned, honeycomb performs its required task with an absolute minimum obstruction to fluid flow (Fig. 3). Such improved design efficiency can, in many instances, more than offset the cost of the honeycomb.

Others in this series. Copies sent on request.

1. **Honeycomb Sandwich Panels**
2. **Honeycomb Sandwich Materials**
3. **Successful Honeycomb Sandwich Design**
4. **Honeycomb Design Characteristics**
5. **Honeycomb as an Energy Absorber**
6. **Varieties of Honeycomb.**

6283

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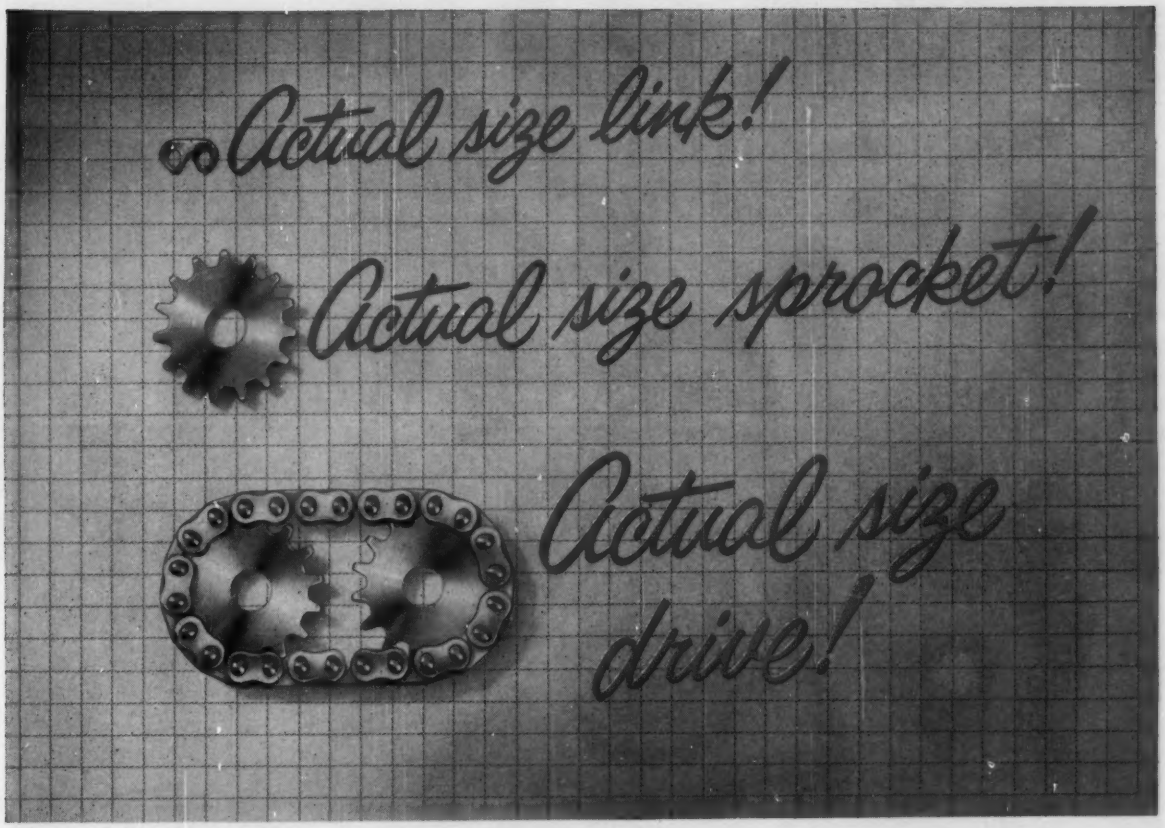
HEXCEL® PRODUCTS INC.

World's Largest Manufacturer of Honeycomb Products and Materials

Executive Offices: 2332 Fourth Street, Berkeley 10, Calif.

Distribution throughout the United States and Canada

Circle 475 on Page 19

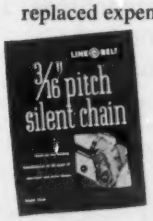


. . . and actually over 98% efficient

LINK-BELT 3/16" PITCH SILENT CHAIN

Complete drives as small as two inches! Weight as little as .07 pounds per foot! Efficiency better than 98%! Link-Belt 3/16-in. pitch silent chain is the perfect combination of compactness and split-second precision.

At high or low speeds, this chain is quiet, positive, smooth. In fact, with its unique link design, it's the smoothest-running chain in use today. In many limited-space applications, it has replaced expensive, precision-cut gear trains. And its versatility makes it ideal for a wide assortment of equipment—ranging in diversity from cigar-making machines to guided missile controls.

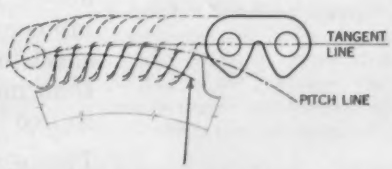


Available in carbon and stainless steels . . . for ratios up to 12:1, speeds over 7500 rpm. For full details, contact your nearest Link-Belt office. Ask for Book 2510.

LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

NO CHORDAL DISTURBANCE!

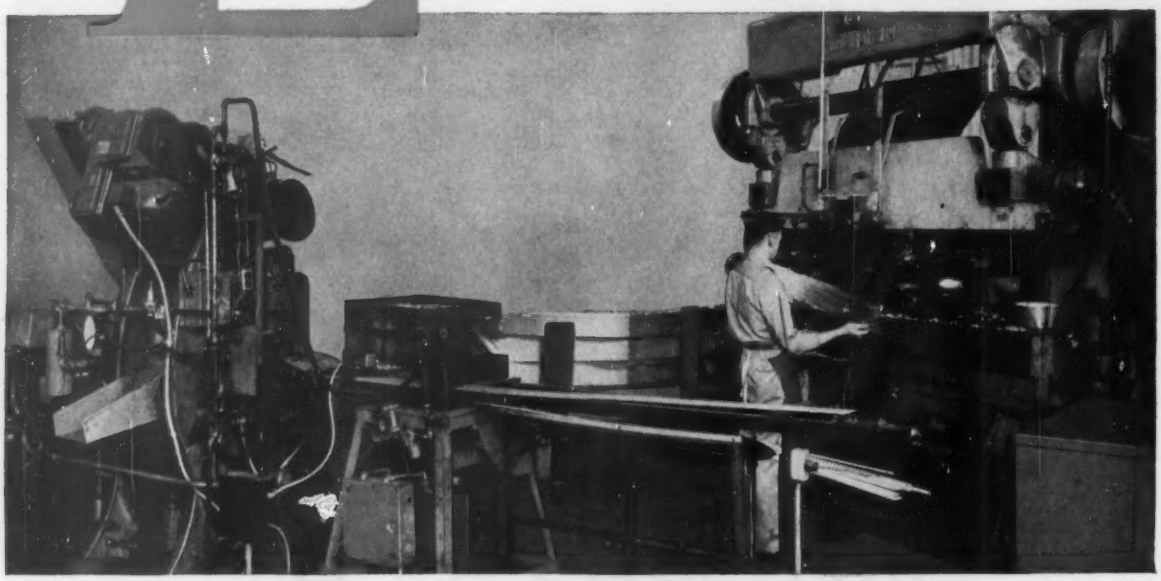


Exclusive link form of Link-Belt 3/16-in. pitch silent chain permits chain to enter the sprocket wheel on a line tangent to its pitch circle, thus eliminating the undesirable effects of chordal disturbance.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices, and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

Circle 476 on Page 19

E is for EFFICIENCY and ECONOMY



Efficient operation is the straight road to economy. And economy in *our* plant cuts *your* cost of production.

At MIRRO, high-speed, automatic equipment lets us turn out *more* work with *less* work—and at a reject rate that's almost disappeared off the bottom of the chart. In the unit above, for example, feed, perforation, and cutoff operations are combined, to supply a single operator with prepared sheet for final forming. This is only one of many machines that make MIRRO a highly efficient and economical source for volume quantities of aluminum components.

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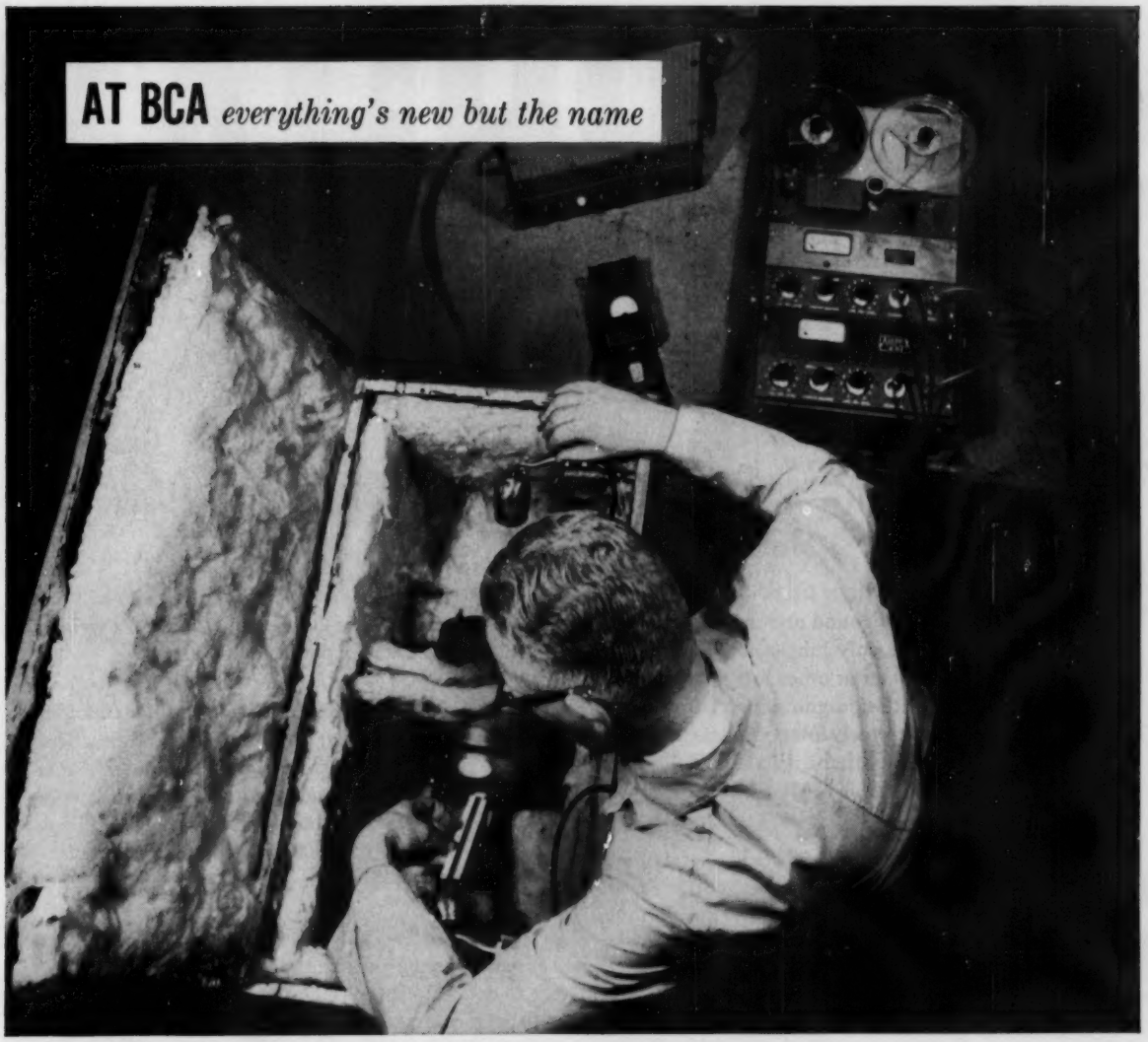

NEW POLYPHONIC ANALYZER

probes ball bearing noise in electric motors

In the double-celled acoustic chamber above, electric motor bearings are analyzed under operational conditions. An electric motor is run inside the split, acoustically-insulated chamber. In each cell, sound from the running motor is picked up by sensitive microphones, measured for noise level, then tape-recorded stereophonically. When the stereo tapes are played back and analyzed for frequency content, it's possible to pinpoint the cause and source of noise in a motor, and to eliminate it through design changes in either the bearings or the motor itself.

This BCA-developed bearing research tool is being used to test bearings . . . evaluate bearing lubricant formulations . . . check the value of varying metal combinations . . . determine ideal surface finish and contour of bearing raceways and balls.

In the Temperature-Humidity-Controlled Instrumentation Room at BCA, this and other specially designed devices test BCA bearings for use under conditions *often identical to operating conditions specified by the customer.* The result: BCA bearings which meet or exceed performance specifications on the equipment for which they are designed.

There's a complete BCA line of ball bearing sizes and types for almost every kind of industry . . . automotive, earth-moving, agricultural, for example. This, plus BCA's extensive new research, testing and production facilities, assure bearing users of a dependable source of durable ball bearings to meet almost any need. For information, write Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA

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ball bearings

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Circle 478 on Page 19

GRAPHITAR®

(CARBON-GRAPHITE)

THE VERSATILE ENGINEERING MATERIAL THAT POSSESSES MANY UNIQUE AND PRACTICAL ADVANTAGES FOR A VARIETY OF APPLICATIONS

MINIMUM LUBRICATION REQUIRED—Because of the controlled porosity and non-melting nature of GRAPHITAR, the only lubricant GRAPHITAR bearings need is water or other low-viscosity fluid. Any such fluid with non-gumming characteristics will provide an extremely low coefficient of friction and assure long life of the GRAPHITAR parts.

RESISTANCE TO CHEMICAL ATTACK—GRAPHITAR has the ability to withstand the action of almost any chemical, with the exception of the most highly oxidizing re-agents in hot and concentrated form. GRAPHITAR parts, for example, operate efficiently in steam, chemical and gas valves to provide a corrosion resistant material operating under the most adverse conditions.

MECHANICALLY STRONG – GRAPHITAR will not warp or distort even in high pressure applications. Compressive strength up to 45,000 psi and transverse breaking strength from 3000 to 16,000 psi, depending on the grade.

HEAT RESISTANT—GRAPHITAR is not affected by heat under neutral or reducing conditions. Temperatures of oxidation for most grades is approximately 700 degrees F. In addition, GRAPHITAR engineers have developed a special oxidation resistant grade of GRAPHITAR that has been exposed in an oxidizing atmosphere (air) of 1200 degrees F. and after 200 hours, it showed a weight loss of less than six per cent.

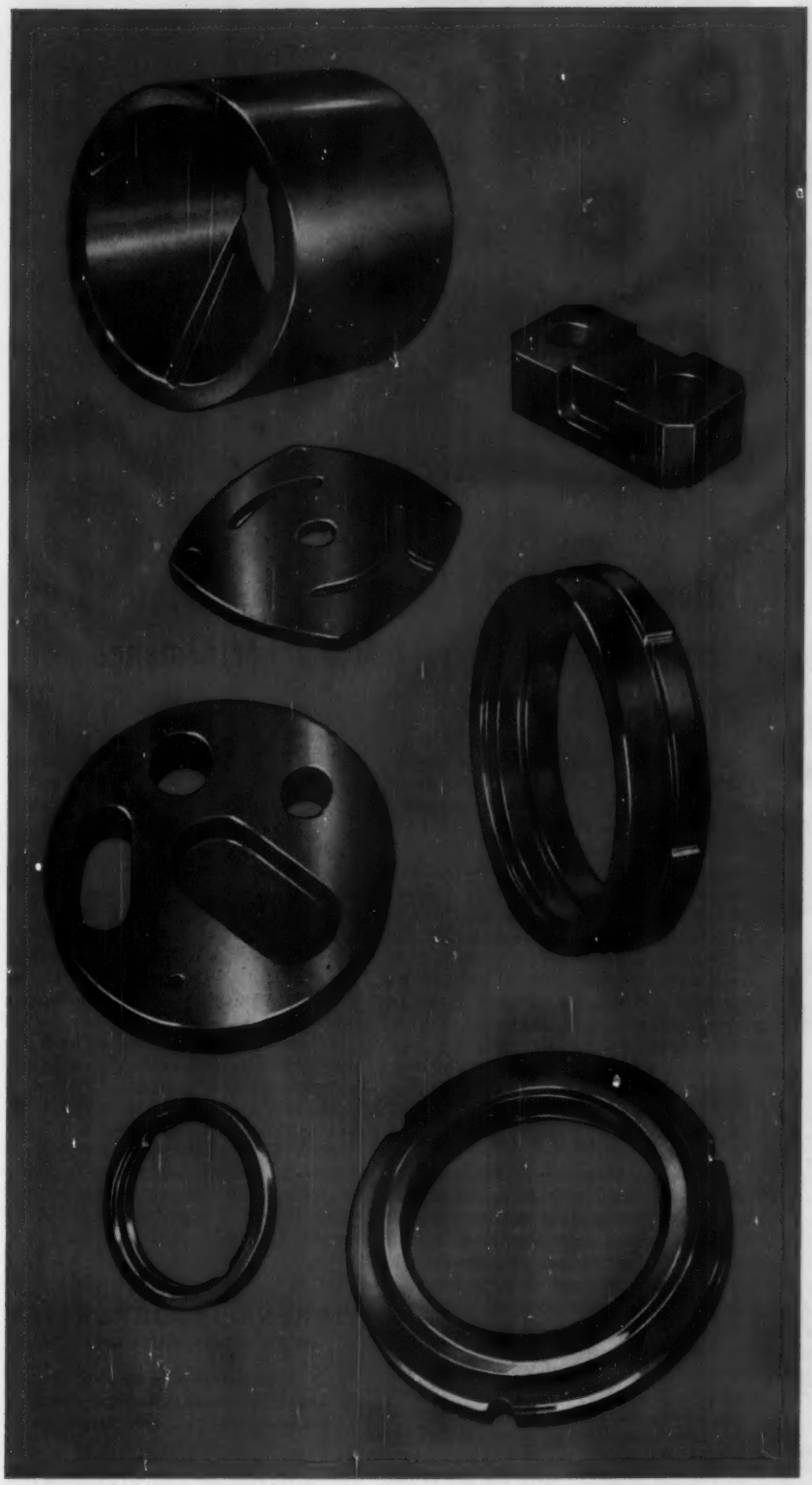
MOLDABLE—GRAPHITAR has excellent moldability properties that make possible and practical unusual shaped parts. Design requirements such as ears, face slots, and outside diameter notches can easily be incorporated into GRAPHITAR parts without secondary machining and finishing operations.

MACHINING—The United States Graphite Company operates an excellent finishing department to do all finishing operations to the most exacting specifications. GRAPHITAR may be ground to size or shaped with a tungsten carbide or diamond tipped tool to tolerances as close as .0005". When surfaces require a high degree of precision in flatness, lapping and polishing equipment are employed and accuracies within three light bands can be produced.

LIGHT WEIGHT – GRAPHITAR is lighter than magnesium and is being employed increasingly in the aircraft and missile fields. The weight per unit volume of various GRAPHITAR grades is as follows: 102.8 to 116.03 pounds per cubic foot, .0595 to .0672 pounds per cubic inch, .952 to 1.074 ounces per cubic inch.

THE UNITED STATES

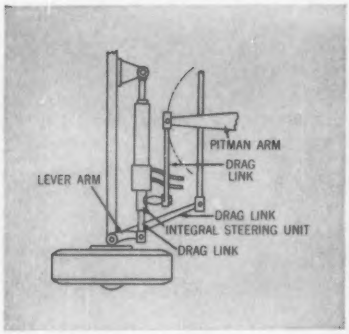
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



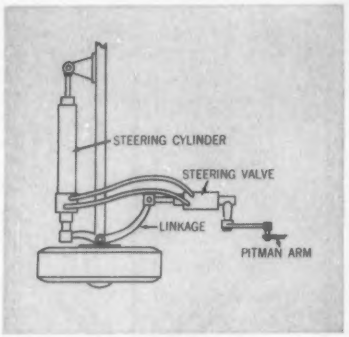
GRAPHITAR'S many desirable characteristics make it the ideal engineering material for such parts as rotary seal rings, packing rings, pressure joint seals, bearings, fluid coupling seals, metal backed bearings (Graphitar inserts), piston rings, pump liners and vanes. If you would like more information on GRAPHITAR, the versatile engineering material, send for Bulletin No. 20 today.

GRAPHITE COMPANY

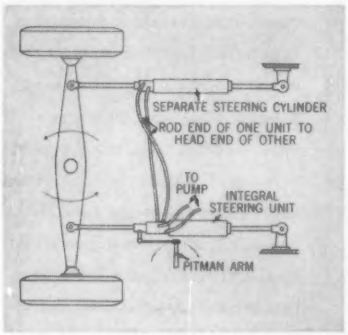
DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN



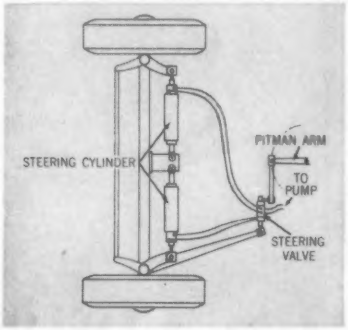
INTEGRAL LINKAGE system combines servo valve and steering cylinder with rod end fastened to frame and valve end to drag link.



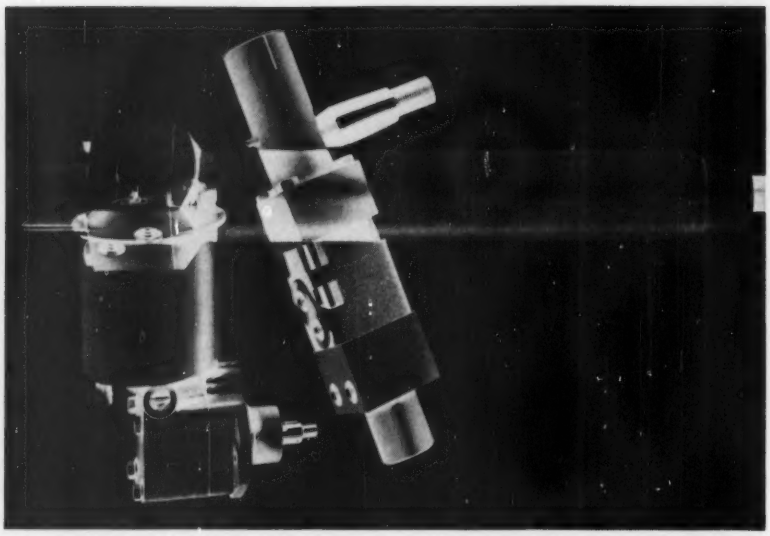
REMOTE LINKAGE system has separate servo valve and cylinder. Servo is mounted at most convenient point with cylinder located for maximum thrust.



COMBINED INTEGRAL-REMOTE system servo valve controls both cylinders. When integral unit (bottom) extends, remote unit (top) retracts.



REMOTE DUAL system uses one remote servo valve, offers best possible thrust conditions plus considerable installation flexibility.



FOR AXLE LOADINGS 1500—128,000 LBS.

New VICKERS power steering systems use standard units, offer custom performance

Performance benefits normally associated with custom designs plus the economy of standard, production-built components are combined in new Vickers power steering systems. The cylinder, servo valve, and pump—key elements in the power steering system—are always perfectly matched to system needs because Vickers builds the *complete system.*

Either remote or integral systems can be provided for the complete range of axle loadings from 1,500 to 128,000 lbs. All vehicles use the same servo valve—holding engineering and installation time to a minimum and reducing inventory requirements for manufacturers building several sizes or types of equipment.

Operating Economy—Systems are designed for high pressure operation (to 2000 psi) permitting smaller pumps, lines, reservoirs, valves and cylinders to be used. Further economy results because each basic size of steering unit is capable of a wide range of axle loadings. This permits some manufacturers to use a single size of steering unit for their complete line of vehicles. For example, in a single cylinder installation, the Model SC-26 cylinder can be used for any axle loading from 16,000 to 64,000 lbs.

Further economy over the life of the system results from the minimum number of moving parts required by this design and from its rugged construction. All cylinders are double walled to eliminate the common hazard of functional damage to cylinder walls from flying debris. Exclusive design vane pumps last longer, permit easy cold weather starting because pumping doesn't begin until after engine fires and comes up to speed.

Complete Responsibility – Both the equipment builder and ultimate user benefit because Vickers designs and builds all system components. In addition, a staff of power steering specialists is available to work with customers on specific development and application problems.

When equipment is being built for the export market, worldwide stocks and complete interchangeability of all parts made in Vickers plants throughout the free world offer added benefits.

More Data – Design advantages, dimensions, ratings, and other data are available in Bulletin titled "New Complete Power Steering Systems." Write for this 20 page Bulletin M5110.

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You Need These for Power Transmission

Bimetallic bushings and washers . . . babbitt on steel, bronze on steel (single or double-sided), aluminum on steel or rolled bronze—all have something to offer to the design of power transmission equipment.

Load carrying capacity, corrosion resistance, score resistance and wear resistance are important and necessary features in solving your design problems.

Here's another bonus: a full-time design and service engineering group is ready to help design your specific use of Johnson's bimetallics.

Contact us for more information on how Johnson Bronze Co. can help serve your power transmission needs.

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NOW...

Robbins & Myers Calculates a New Motor Design EVERY 1 to 6 MINUTES!

R&M Engineers Explore Hundreds of Design Combinations to Achieve OPTIMUM MOTOR PERFORMANCE!

How many ways *could* a motor be designed — a polyphase motor, for example? At least 27 basic variables offer 27^{27} (30 zeros) possibilities! Theory, of course, but still there's a colossal number even after obviously impractical designs are ignored. Working with slide rule, an engineer can calculate maybe four designs per day . . . and that's the time-consuming way it was done once. But now ROBBINS & MYERS engineers can explore hundreds of design possibilities, using their Data Processing System. With infallible accuracy, IBM's 20,000 digit "Magnetic Memory" is able to calculate a new motor design every one to six minutes! Because R&M engineers can now explore hundreds of design combinations before they make a final decision, you get the one motor that will deliver optimum on-the-job performance! And at no extra cost!

"Mechanized" mathematics at ROBBINS & MYERS also gives engineers more time for design *vision* and *decision*, which no machine can possibly provide . . . and enables them to improve existing motors by probing alternate design possibilities.

If you are ordering integral or fractional HP motors, or series motor parts, remember this fact: *the greater the number of practical design possibilities the manufacturer explores before the motor is produced, the better the motor will perform!* When your motor comes off the assembly line at ROBBINS & MYERS, you can be certain you are getting the best design possible, perfectly adapted to your requirements, and quality-built to perform dependably for years to come!

ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

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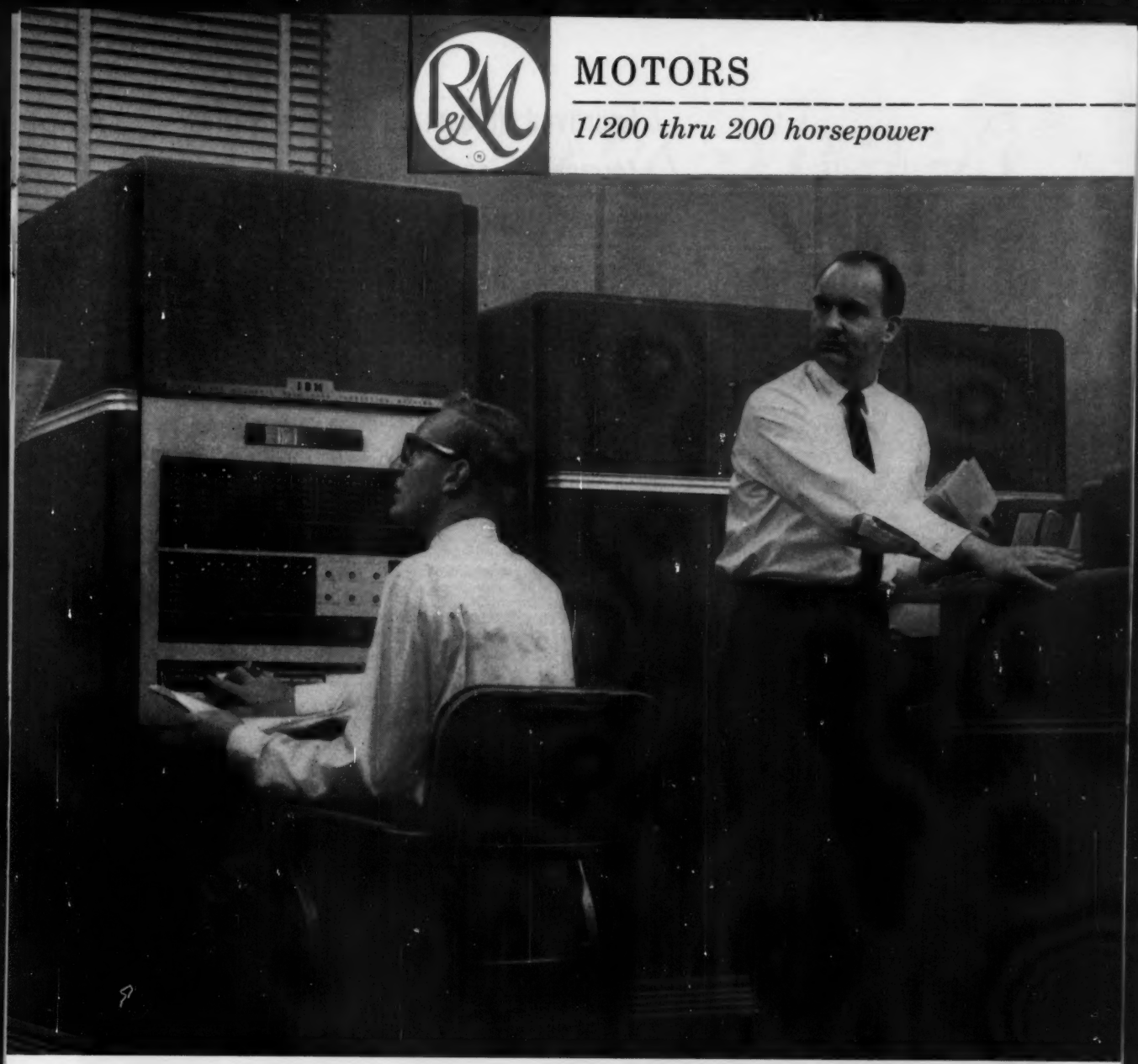
MOTORS

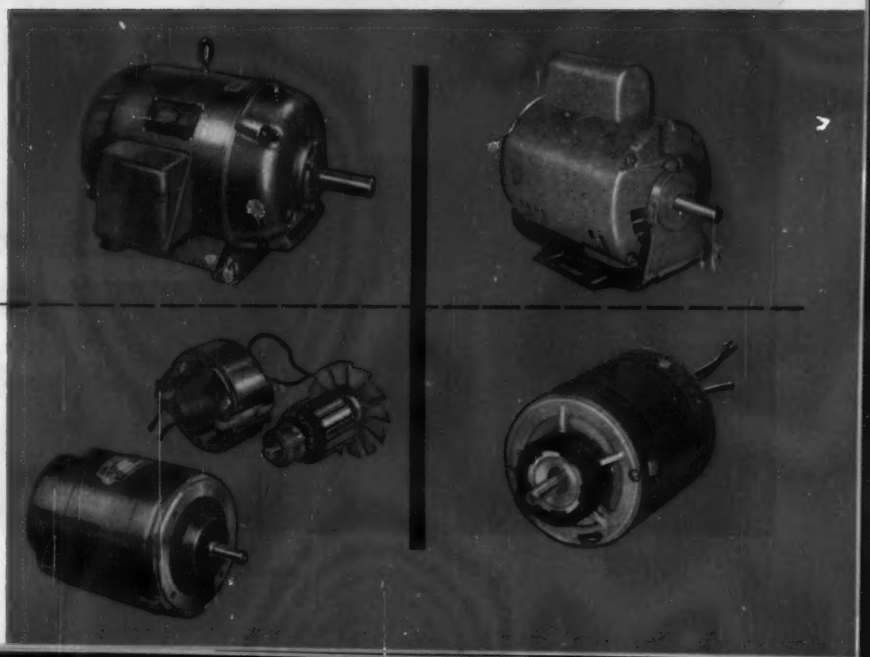
1/200 thru 200 horsepower



Design answers in seconds from IBM 20,000 digit magnetic memory!

Integral Motors (left), range from 1 to 200 HP in single-phase, direct current, polyphase, totally-enclosed fan-cooled, and explosion-proof types.

Standard Fractional HP Motors (right), are available in polyphase induction, capacitor start, resistance split-phase, and permanent split capacitor, in open and totally-enclosed types.



Precision-Made Universal Motors and Series Motor Parts (left), enable manufacturers of electric power-driven equipment to make the motor an integral part of their product.

Business Machine and Commercial Appliance Motors (right), are available in standard or custom designs.

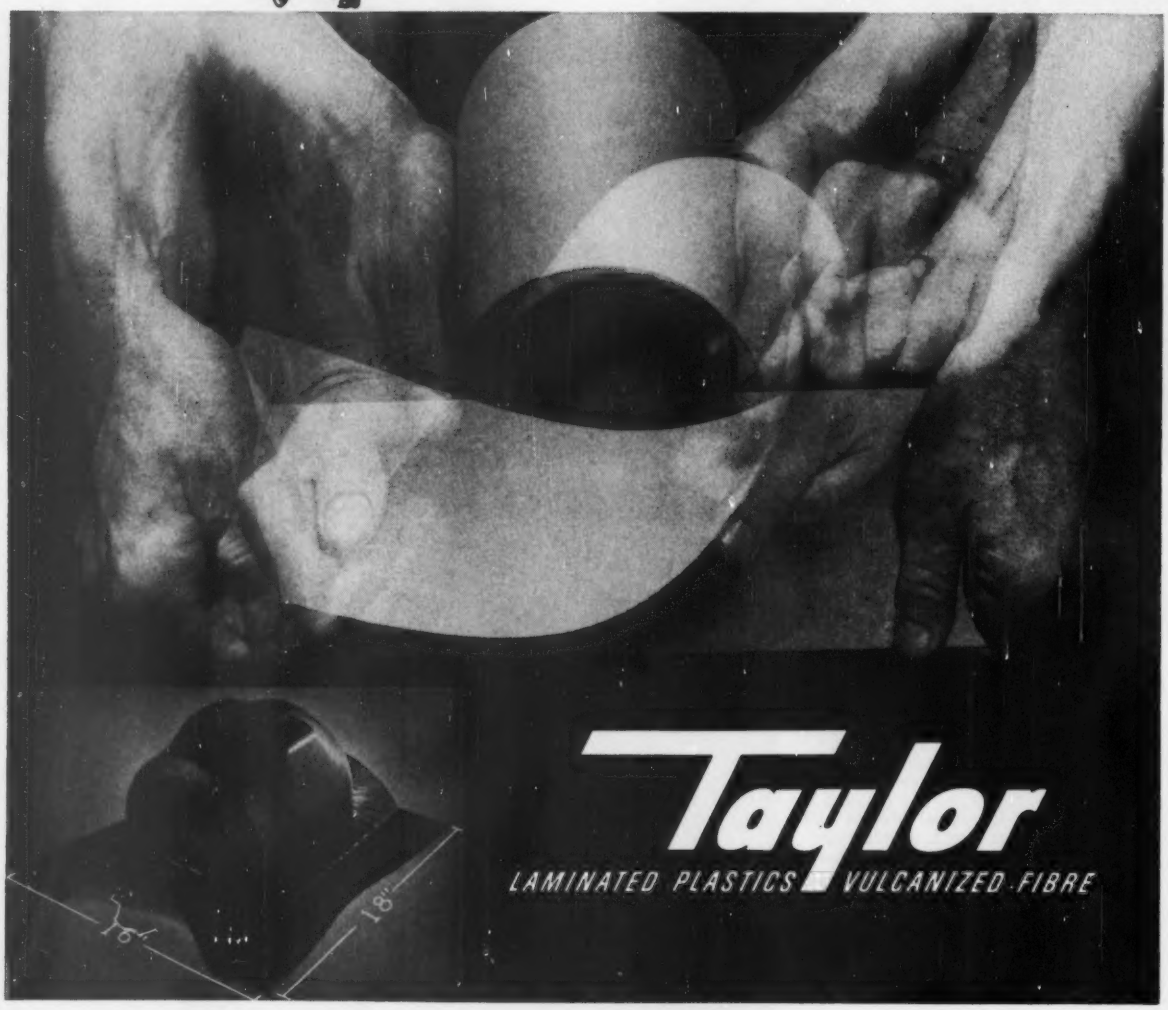
New "Taylorite"® is a veritable workhorse

Improved Vulcanized Fibre has the formability and strength to be deep drawn into many intricate shapes

There has been a big change in Taylor Vulcanized Fibre, including the name. New processing equipment and atmosphere-controlled storage facilities have enabled us to make major advances in overall reliability—including uniformity from lot to lot—at no increase in cost to you. Among the improvements are better formability and capacity to be deep drawn. These, combined with greater tensile strength, flexural strength and dielectric strength, make new Taylorite an ideal material for 1001 industrial applications.

Samples are available. Test them for yourself. Put them under tension, flex them, compress them, form them. You will find that new Taylorite survives your severest tests. And remember, Taylor offers complete design and engineering service. Write for Data Sheet 2-0 and samples. Taylor Fibre Co., Norristown 47, Pa.

TAYLORITE vulcanized fibre meets deep draw requirements. Material used was .060 in. thick sheet of commercial grade. Forming of the welder's helmet was performed under normal production conditions.



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HOKE Flow Sheet 2

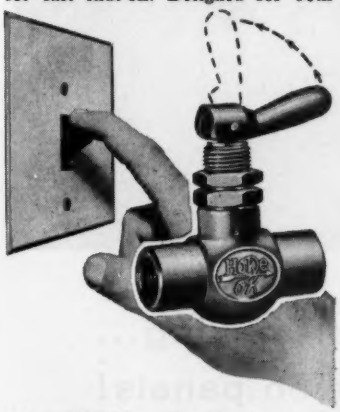
HOKE REPORTS ON FLUID CONTROL

WE'VE PACKED PERFORMANCE IN A PACKLESS VALVE

How to be "Flip" About On-Off Control

We've turned the tables on electrical engineering profs who try to demonstrate current flow by describing a valve on a pipe. Our switch-action toggle valves stop and start flow just as easy as: Flip, it's on! — Flip, it's off!

These valves perform a basically simple function, but a lot of engineering went into them to insure perfect performance. Many are used on precision test equipment and for control applications, often in conjunction with automatic controls as a manual safeguard for fast shut-off. Designed for both



gas and liquid service, the stem seals are tight enough for most vacuum work, too. We certainly can't be flip about these specifications.

Hoke manufactures two types of toggle valves. The 450 Series has maximum operating pressures up to 200 psi. These are spring closing valves made in ¼" and ⅛" pipe sizes which can be classified as "miniatures", measuring less than 2" in height in the closed position. They are normally supplied with moulded, black, Nylon handles, but colored handles can be supplied for special identification purposes. Panel mounting lock-nuts are included as standard equipment on every valve.

The second type is the 490 Series, a cam-closing toggle valve for service up to 2000 psi. They'll give you the same quick, positive action as the 450 Series, while performing the toughest laboratory and process jobs. The 490 and the 450 are excellent performers on non-critical high vacuum. They can be helium leak-tested for this purpose.

So, if you're interested in switch-action flow control, investigate the Hoke toggle valves. We'll be happy to equip you with complete technical data. A check in the coupon to the right will bring you the facts.

The development of packless valves has so greatly reduced the problems of handling high pressures, temperatures and vacuums, and dangerous fluids that engineers designing such systems can now spend more time curled up with the Hoke Corrosion Chart.*

With this extra time, many have dreamed up weird applications for the Hoke 440 Series bellows seal valve, trying to snare us in our own semantics. In a rash moment, we boasted that this valve could be modified for almost any application. Actually, the 440 can be modified to work at high pressures (up to 2000 psi), for high temperatures (up to 1000°F.), and for special connections such as tubing, socket welding, and silver brazing.

Aside from this horn-blowing, here are the dry facts. The basic design includes a stainless steel body, inert arc-welded bellows assembly, Teflon gaskets and Teflon stem point discs. This is only the starting point. Minor modifications make so many models available that almost any problem, including liquid metal handling, can be solved.

Hear what a disbeliever said: "I did not believe that the modified valves would satisfy all my requirements, especially to keep a high vacuum of the order of 10^{-8} mmHg under a wide variation of temperatures; however, I now acknowledge that the modified Hoke 440 valves fulfilled their duty perfectly." This came from The Martin Company, where we sent 440's for use in cesium vapor up to 400°F. Special

The cesium boiler shown above uses a modified version of the Hoke 440 series bellows seal valve (at right) to handle high vacuum of 10^{-8} mmHg and cesium vapor at temperatures up to 400° F.

modifications made these valves readily usable on a cesium boiler and converted an infidel to the true valve.

If you work with critical high vacuum, high pressures, high temperatures and dangerous fluids, proceed with care. Ask for our Packless Valve Bulletin to reap a harvest of engineering plums.

** Makes good reading if you're handling corrosive agents. Write, and we'll send you one.*

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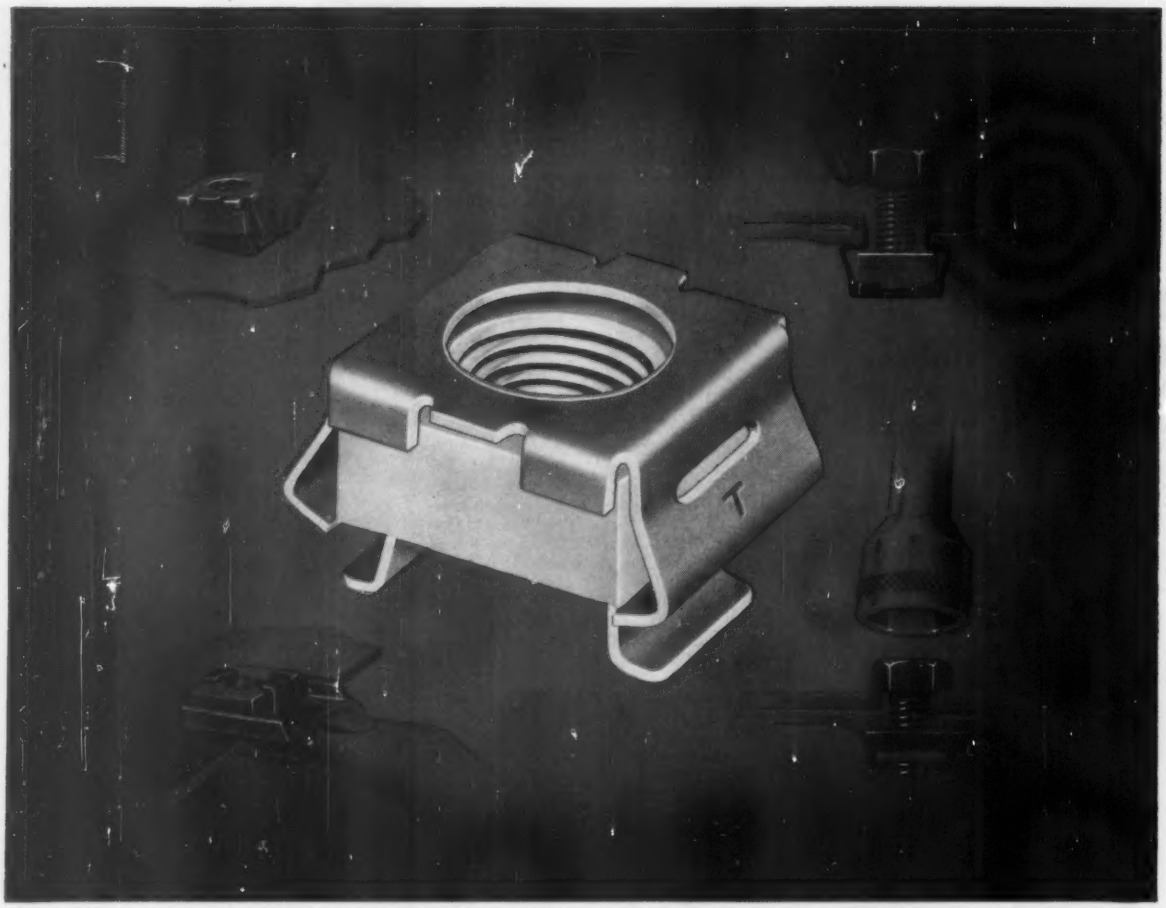

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DESIGN
July 21, 1960

Don't Rock the Boat?

IT is the fate of creative engineers to have to produce ideas under the direction of management that is inherently resistant to new ideas. That engineers are keenly sensitive to this attitude is amply borne out by the results of surveys.

The creative engineer must be an innovator, a radical, a progressive. But management's role is to be conservative. Management cannot fall for every proposed innovation. We have recently witnessed the spectacle of a top manager of a large corporation who was so enamoured of new distant-future projects that the sound day-by-day growth of his company suffered. He has been replaced.

How to control and direct the youthful enthusiasm of creative people without seeming to be hostile and unsympathetic is one of the problems that too few management people have learned to handle. Yet upon the successful administration of creative talent depends the very life of the company. Eugene Raudsepp's comprehensive study in this issue offers many valuable pointers.

Engineers, for their part, have not always oriented themselves toward management's viewpoint. They may have become too easily discouraged by the man-from-Missouri attitude. They should remember that one of management's functions is to maintain stability. And when management says "Don't rock the boat" it doesn't mean "Abandon ship."

Colin Carmichael

EDITOR

17 *ways engineering management can build and improve a* CLIMATE

EUGENE RAUDSEPP
Research Consultant
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New York

ENGINEERS are a creative lot. Employers hire them because they are that way. But it's often true, unfortunately, that employers divert and suppress this natural bent. Then valuable creativity turns dormant, and the engineers themselves may leave the scene.

To remedy this condition, recent studies prescribe a hands-off attitude by management. Along that line, this article gives do's and don'ts by which management can generate and maintain a climate in which creativity flourishes.

There is little doubt that the climate for creativity is set by management. Attitudes of management toward creative people can operate either as catalysts that release their potential or as barriers that stifle creativity. Two of the most important management attitudes favorable to creativity are expectation and recognition. As E. Finley Carter, director of Stanford Research Institute, says,

> It has long been my observation that people strive to live up to what is expected of them. They are willing and eager to push beyond the limits of their known capabilities when they are faced with a challenging

task, and feel aware that they are expected to deliver. In any creatively oriented group or organization, it is important to have leadership which has confidence in its staff and thus *expects* a challenging level of achievement. Staff members who justify such confidence develop a self-confidence which is itself regenerative.

The factor of *recognition* follows logically. The striving for perfection . . . forces introspection and self-examination. The creative person feeds upon recognition by his colleagues and by his leaders. . . . It is the reward we naturally seek.

In a similar vein, psychiatrist Dr. O. Spurgeon English of the Department of Psychiatry, Temple University Medical Center, emphasizes the great value of these two factors:

Recognition of the fact that an individual has something to give goes a long way toward making him feel that he can give it. Therefore, an organization must indicate to its talented personnel that it expects each of them to produce. This can be stated in such a way that it is not anxiety producing but is, instead, ego building. Do not say, "We expect you to produce or we will throw you out," but say, "We have employed you to be creative and productive for us, and we want to help you all we can to do this thing."

Of course, management has to make sure that creative technical people join their organizations in the first place. Certain managements with non-creative attitudes almost inevitably attract and hold people with similar attitudes. In addition, it has to be pointed out that the current selection methods, particularly personality testing, more often than not screen out the really creative individuals, since conformity and "adjustment" have been factored into these tests.

Perhaps a more fundamental obstacle to the establishment of a creative climate is the bifurcation or conflict in the value systems of management and technical personnel. Professor Ross L. Mooney, Ohio State, observes,

The technical man tends to take a stance which faces nature, assuming his authority is derived from what he knows about nature . . . The manager tends to take a stance which faces society, assuming his authority is derived from lines of institutional organization . . . These two sources of authority, nature and society, can be quite confusing inside an organization which emphasizes both. When the technical man is in his groove . . . he does not want to be bothered by a

manager who . . . wants a report or project proposal. When the manager is in his groove . . . he does not want to be badgered by requests of a technical man for some exceptional procedures in order to work out a technical problem.

Values and motivations of the two systems tend to be different. What the technical man uses to motivate himself is often his curiosity about nature, his delight in communication with others who can take an adventuresome intellectual journey with him, and his hope of increasing mastery over an intellectual problem. What the manager uses to motivate himself is often his desire to operate a smoothly functioning organization, his delight in being identified by others with the successes of his organization, and his hope of increasing status in the social system.

With these differences in timing and motivation, tensions easily develop between the two groups. After a number of rebuffs in which men of each kind see themselves overlooked or rejected by men of the other kind, there is a tendency toward the formation of separatist groups around the two different poles of authority. Differences are heightened by the shared feelings expressed inside each group. It is difficult for men at these two poles to then see men at the opposite poles as companions on a common journey. Men in the opposite camp are seen as role-takers, job-holders, categories of the institution, but not as men of flesh and blood, like oneself, with whom one can share, man to man, in an enterprise inclusive of both. There is no good psychological meeting ground.

The following sections of this article describe problems of creativity for which management may need to make policy.

Cultivate Nonconformity

The one single factor that has withered more potential creativity than any other is the sanctioning of conformity. George A. Peters and Sheldon Gardner describe the dangers of conformity in the industrial environment:

> It is rather difficult for those in positions of management, administrative, or supervisory responsibility to accept anything but forthright organizational conformity from their personnel. All too often, the critical discontent of the research scientist becomes something more than a work habit. It may spread to a general dissatisfaction with the work surroundings, particularly

Tips to management for Improving Creative Climates . . .

- Gain better knowledge of creative people. Understand their personalities, their powers and foibles, their needs and motives, their fears, and their enthusiasms.
- Improve understanding of the nature of creativity and the difficulties implicit in the creative process.
- Adopt selection procedures capable of "screening in" genuinely creative people. Do not hire people primarily on the basis of getting along with others. Encourage constructive nonconformity and individual differences.
- Learn the internal and external incentives to creative effort. Spell out carefully and demonstrate incentives for success.
- Allow creative departments to have an important part in management's long-term plans and keep creative people informed about important aspects of company operations, policies, and goals.
- Place a high value on creative effort. Provide the inspirational beginning for a creative project. Show faith that creative people will be creative in their solution to problems. Show interest in projects at hand and recognize progress made. Realize that creativity thrives on recognition, praise, and understanding.
- Encourage in both word and deed. Provide moral support and respect. Have a genuine desire to see creative people succeed. Establish a receptive and co-operative climate.
- Recognize accomplishment and deliver adequate rewards for accomplishment. Honestly evaluate creative ideas and see to it that individuals receive proper recognition for their ideas.
- Develop an open-minded, receptive, "let's-go-further" attitude. Have respect for creative people's opinions. Give creative people a chance to try out ideas without prejudicial criticism.
- Convince technical people that they individually are expected to take responsibility for initiating new work and new ideas, and that management will back them up. Allow them to guide their own work. Provide everybody

during periods of stress regarding work projects. It is also quite easy to displace critical attitudes onto likely nearby targets as a defensive reaction to the almost inevitable occasions of personal frustration to difficult, abortive, or unsuccessful research effort. . . .

Undue pressure for organizational conformity certainly does not provide the best climate for research since nothing can be so devastating to uninhibited creative thinking as that social pressure which makes the scientist feel uncomfortable for exhibiting any originality. In this situation, the scientists's behavior may become accentuated, resulting in further organizational conflict which reduces his effectiveness and efficiency. . . .

To avoid censure, the scientist may arbitrarily constrict the parameters of his research . . . To avoid liability, the scientist may reduce the probability of research failure by more conservative and stereotyped efforts of a more defensible nature.

Dr. W. D. Lewis, of Bell Telephone Laboratories, comments on the need for the acceptance of intelligent, constructive nonconformity from the technical person:

Industrial groups based on respect for nonconformity are not only more creative than more conventional groups, but are also more attractive to the highly creative people they most need to attract.

Because its product, by definition, is novel, a research department unlike most other parts of a business organization cannot afford to standardize its product or its personnel.

Create Flexible Controls

This inhibitive factor relates to the imposition of overly restrictive controls by management on creative work. To be sure, many managements are driven to this because of the failure of creative departments to meet time schedules and budgets. But, the real causes could be managerial: Poor initial project choice and planning, unclear established objectives, unrealistic time and budget allotments. If management proceeds by imposing even stricter controls, engineers feel that management is arbitrary in scheduling, authoritarian in making decisions about projects, and blind to peculiar project requirements.

More flexibility in managing creative personnel is indicated by Dr. Sidney M. Cantor, a consultant to industry:

The kind of people who, for the most part, rise to positions of control in large companies do so because of particular personal characteristics which invite and extend rigidity in ideas and attitudes. . . . Energy for

with areas of freedom and self-direction. Keep the organizational structure flexible.

- Recognize technical people's dedication to their field of specialty. Accept the long-range goals and objectives of creative work.
- Provide funds and facilities for creative work.
- Constantly and consistently reflect the sincerity of published objectives and policies.
- Bring people together who stimulate each other. With the more creative, see to it that group work is on a strictly voluntary basis, that is, let them determine when to be alone and when to seek each other out. Realize that the team approach will solve problems but that the real advances in creative work are made by men who enjoy the freedom of selecting their own challenging problems and solving them without the restriction of unrealistic time-schedules.
- Avoid over-regimentation and gearing of efforts to a too-rigid time-table. Recognize that a good group can supply its own brakes without stifling creativity. Realize that pressure and push for a desired result often hamper creativity. Minimize deadline pressures, trivial routines, and administrative details. Know that informality and freedom are necessary to spontaneity of creative thought.
- Consider individual personalities in making assignments. Actively seek out, develop, and encourage those with creative ability.
- Be willing to take calculated risks. Recognize that the attitude of no-risk-taking, this-has-gotta-pay-off is inhibiting of true creative thought.
- Maintain open communication channels up and down.
- Provide parallel paths of advancement with management. See to it that salaries of top creative personnel are on a par with management.
- Give prestige to creative people. Provide personal recognition. Establish honors and distinctions of the purely professional sort. Provide opportunities for social and professional recognition of creative talent.
- Provide leadership which will press for the development of a creative environment not only in tangible things, but in the nature of creativity. Strive for an atmosphere of encourage-

arriving at the high place initially . . . is then used to extend the lines of control rather than to break down the controlling walls. . . . Anti-creativity is self-perpetuating.

I am thoroughly convinced that we need a new approach to defining the place of the creative individual in the industrial organization. He is going to have to be treated more as an independent and less as an employee if his full value to the company as a thinker and the full value of his extensive training and education is to be realized. Something like this is being approached in some companies.

Remove Limit-Setting Fences

One of the strongest factors inhibiting the establishment of a creative climate in the corporate setup is the management philosophy that expresses itself in "creativity—within limits," or, "can't afford to take chances." Where this philosophy rules, the challenge and problems given to technical people are too specific and well defined, or too short range to result in the most creative contributions. Major emphasis is on functional improvements on an existing innovation rather than developing a completely new product. Those responsible for improving the product are asked to follow an orderly, direct, prescribed pattern. This emphasis on immediate payoff results indicates management's fear of the characteristic insecurity in fundamental creative work.

Match Projects to Engineers' Interests

The engineer in the corporate setup has to work on problems dictated by the needs and exigencies of the company. This means that he frequently has to work on problems that do not interest him particularly. The consequence is reduction in creative performance. Richard N. Wallen, Personnel Research and Development Corp., explains it:

> When we are fascinated, we feel the problem pulling us. We do not feel pushed into it. The fascinating problem is one that we choose, one that somehow belongs to us. People do not need to be driven to do things that have an intrinsic attraction.

Put Teamwork in Its Place

Another deterrent to maximum creativity lies in teamwork and collaborative projects. Teamwork in engineering and science, and various group techniques in industry, have largely replaced the individual investigator. The need for disenchantment with collaborative enterprises has been indicated by many authorities:

> Dr. Leo Steg of General Electric Co.: "The creative nature of the inventive process is an individual characteristic and not generally a group characteristic. . . . Group thinking, 'brainstorming,' and other attempts at group creativity in the creative process probably are not major factors in scientific creative accomplishment."

> Paul Trentham of Westinghouse Electric Co.: "We can not get away from the fact that an idea, whether it is the Big Idea or whether it is a small idea within the Big Idea, originates in the mind of a single man."

> Professor Brewster Ghiselin of the University of Utah: "Team action guided by a formula, as in 'brainstorming' is too mechanical and rudimentary to serve the needs of highly creative minds. It can encourage the timid and stimulate the habitually inactive to do more than they would if left to themselves. . . . Pick the best men, and let them determine when to be alone and when to seek each other out."

The entire problem of whether creativity should be encouraged through individuals or through groups is controversial, Table 1. The very creative individual is frequently in conflict with the conformist character of industrial work, where teamwork predominates. He lacks the "passion for anonymity" required from team members. Since creative brilliance, in the industrial environment, is often considered secondary to the ability to get along, the highly creative individual is either coerced to conform to the rules of the group or leave the group.

Tips . . .

ment, recognition, and mutual respect.
For supervisors, particularly:

- Recognize, encourage, stimulate, inspire, enthuse, and reward creative effort. Bolster creative persons' self-confidence. Lead by suggestion rather than by specification.
- Delegate responsibility and assign work. Safeguard areas of freedom. Do not dictate approaches to problems.
- Give a new idea a fair hearing or consideration. Identify those who contribute to invention. Encourage individual effort. Be able to accept others' ideas without any feelings of insecurity or jealousy. Give credit fairly. Encourage interchange of information and opinion within the team, but with freedom for creative people to follow individual leads contrary to group ideas.
- Demonstrate patience, confidence, and enthusiasm in creative work where the goals have not been fully delineated.
- Recognize differences in individuals. Be patient, tolerant, and flexible in thinking and acting.
- Be the group's spokesman before management. Get along with management and have influence on management.

Allow for Personality Differences

The creative technical person is apt to be called "cosmopolitan," "science-oriented," or "outfacing." This means that he places primary emphasis on his status among his peers and recognizes his work as his only real taskmaster. He derives his major satisfaction from his work and prefers to tackle problems which he has chosen himself. The "local, institutionally-oriented," or "infacing" colleague of his, on the other hand, has primary loyalty to the company organization. He is the smoothly operating, conforming, co-operative prototype of the organization man, and likely to be the favorite of management. The creative individual is at a decided disadvantage in competing for advancement with this promoter-type colleague.

Assign Creative Tasks

According to most studies, the one complaint that emerges repeatedly is overabundance of routine and monotony in assignments. Engineers rebel against assignments which they consider subprofessional. Trouble-shooting and control activities likewise contribute to the loss of time for the creative individual.

Adopt the Long-Term View

Because of the tendency of industry to insist upon immediate results, encouragement is only given to expedient ingenuity for practical, short-range ideas that pay off immediately. This tendency is noted by several authorities:

Professor Silvan S. Tomkins of Princeton University: "The chief goals are too developmental, too urgent and utilitarian to encourage top-level creativity."

Hyman Kirtchik, chemical specialist at General Electric Co.: "Unfortunately, top management erroneously believes that the main purpose of research is to turn out hardware. This is extremely disturbing to research people whose product may be a paper or report or a series of failures for several years before the work, materialistic or otherwise, ends in fruition."

Gordon C. Lange, Director of Swarthmore Creative and Development Services: "The trouble with top management is that it keeps looking for practical ideas when a really new idea can hardly if ever be practical by its very nature. Only development will make it practical."

Don't Resist Change

Another reason why management often prefers the ponderous security in slow but sure research and development along prescribed lines, rather than the greater promise in unpredictable creative leaps, is resistance to change. Professor Leo B. Moore, M.I.T., states: "For managements generally, creativity means change, and change means trouble—so let's not have too much of it." Conflict between the old and secure, and the new and unaccepted, usually ends with the victory of the conservative. One of the best answers to those who feel it is necessary to circum-

Table 1—Cases For and Against Group Creativity

Groups	Individuals
A group's effort is more effective than the sum of individual efforts.	A group can only build upon, combine, or evaluate the ideas or concepts of individuals.
Teamwork provides cross-fertilization of ideas.	Group operation creates certain psychological barriers that impede creativity.
There is more stimulation and spark in group work.	Group method is good for problem solving, but problem solving is not essentially creative.
Creativity is more predictable and more controlled in group effort. "The forces of competition between companies will not permit waiting for illumination or inspiration of the individualistic creative variety."	The really creative people need to be alone and free to work solo. "Team approach requires a passion for anonymity, which is abhorrent to the really original thinker."
The trend has been and is toward more and more teamwork.	The true creative worker cannot achieve as much when collaborating with somebody else.
Groups do not have the fear of criticism that often exists in the individualistic approach.	Most of the landmarks of invention have been established by only a few lone investigators.
A creative person will be more productive when working in a group. "The number of stimuli setting his brain in motion is multiplied."	Collaborative projects increase the suppression of individual initiative and courage.
Teamwork stimulates discussion, pooling of knowledge, and exposure to different viewpoints.	Teamwork can only produce superficial, low-quality ideas which are useful for gimmicks, gadgets, and twists.

scribe creative work is the comment by Professor Robert P. Crawford, University of Nebraska:

> The fundamental difficulty is that management feels it has some definite end that must be accomplished. It wants all creative effort directed toward that one invention or process. This implies that all creativity should be problem solving, according to management. But this neglects one of the great ends of creativity—the discovery of all sorts of things and processes. Coal tar dyes, carborundum and penicillin were only side issues to the task that seemed valuable at the moment. This suggests that top management must be creative, otherwise it will be tying its creative men down to problems that may or may not be valuable. A good administrator must be a man who sees significance in what is before him.

Appoint Competent Supervisors

While there is no doubt that top management sets the creative climate in most companies, the one person who actually determines whether creative people reach their maximum potential is the immediate supervisor or chief. The supervisory area in the industrial setup is the most important and the most sensitive of all. Paradoxically, it is here that the greatest hope for improvement lies.

Encourage Independent Thinking

With increasing complexity of industry, the network of mutual dependency is increasing. Professor Ross L. Mooney, Ohio State, feels that this increasing dependency is the very enemy of creativity:

> The more we feel dependent on others, the greater our fright can be at what others may be doing. The greater the fright, the greater the lunge for conformity, the more difficult the position of the innovator, the greater the proportion of energy spent by people in adjusting to one another in the system, and the less energy available for realizing the unique integrations that are requisite for creative beings. Absorption in interdependencies thus dulls our capacity to see and feel ourselves as creative beings.

Give Creators Time

Because of the time pressures in industry, the engineer usually spends too little time on creative thinking. Inability to work for extended periods at a difficult problem—frequently under pressure and in a distracting environment—accounts for a great number of creative failures. Discouragement and an early tendency to give up compound the difficulties.

Occasionally a problem may require further study and mastery of new knowledge and techniques. Failure to learn the requisite materials inevitably forces the creative person to discard the unsolved problem. Where the best creative thinking is desired, crash programs and deadlines frequently fail.

Table 2—Secondary Barriers to Creativity

In addition to the primary barriers to creativity, reported in this article, a survey* finds that these complaints from engineers occur repeatedly:

- Feeling of having to work within the prejudices and preconceptions of management.
- Distrust of originality.
- Specific discouragement of experimentation.
- Emphasis on immediate functional utility of ideas.
- Attempt by management to tell the creative man both what to do and how to do it.
- Refusal to delegate responsibility.
- Lack of management objectives or agreement with them.
- Frequent changes of key decisions.
- Lack of long-range objectives.
- Penurious attitudes of management.
- Absence of effective communications between creative people and top management.
- Horizontal rather than vertical flow of new ideas.
- Failure of management to recognize and reward creative ability.
- Lack of positive attitudes by management toward imaginative ideas.
- Management "stealing" of credit, ideas, inventions.
- Management attitudes: "It was good enough 10 years ago, it's good enough now," or, "We are not going to make any changes."
- Management's tendency to look at a proposal with one question in mind, "What is wrong with it?"
- Poor handling of credit.
- Loss of identification with contributions.
- Lack of understanding of the really creative person and his personality.
- Chaotic administration by research types.
- Belief that laboratory head is not adequately presenting engineers' problems and achievements to management.

*From the study, "Climate and Creativity," conducted by Deutsch & Shea, Inc.

Pare Down Rigid Red Tape

One barrier that works against new ideas and creativity is the strong preference for order that industry instills in engineers. As a result, engineers tend to react with conservative defensiveness and

immediate rejection to ideas that do not fit into a pattern. The rejection mechanism used is the negative and critical approach of either ignoring or banning the new or showing why something new wouldn't work rather than trying to make it work.

Avoid Comfortable Ruts

With the passage of time some engineers, like management, tend to become conservative and habit-prone. The danger inherent in this tendency toward conservatism and caution is that it may stunt the creative growth of the company to a degree where it ultimately fails to cope with competition.

Don't Fret about Failure

Since our society and industry is governed by the premise of success, the specter of failure looms large. In the risk-taking enterprise of creativity, however, failure is a common occurrence. The fear of failure among many scientists and engineers prevents them from daring anything really creative, where the element of failure is uncontrollably large. Failure casts such a fearful shadow over them because of their heavy responsibility for accurate judgment, and the pride they take in their ability to plan and predict successfully.

Speculate—Occasionally

Both our culture and our educational processes teach us to fear speculative thinking. It rewards and sanctions extrinsic practicality and statistical objectivity. Consequently, the most widely used creative method is the "cut-and-try," "empirical," or "brute force" process. This process works without an explicit guiding theory. The worker tries one possibility after another in hope of stumbling upon the desired result. William J. J. Gordon, of Arthur D. Little Inc., observes what he calls "possibility destruction":

> Unfortunately, some contemporary science channels much of its effort toward mere possibility destruction, where for years a corps of trained technicians comes into a lab daily from 9 to 5 to test an almost infinite number of combinations. This large sampling of statistical methodology has captured the confidence of research. Certainly, hypotheses must be proved, but if we investigate the history of invention we find that most important discoveries are triggered by sudden insights based on small samples. Large sampling systems are cautious, safe and consistent with our training since childhood. They are more certain of results, particularly in the sense that ten monkeys left long enough with ten typewriters will produce Shakespeare.
>
> Today's scientist finds himself in a dilemma. On the one hand his fear of novelty, of being wrong, keeps him from the hypothetical end of the spectrum. On

BAD EXAMPLES
or
How Not to Supervise Creative Groups

Sammy Surefoot: He has lots of reliable past experience; is logical and practical. He has tremendous resistance to change, for change may undervalue his past experience and status. He fears that he may be shown up by his underlings; he tolerates very little experimentation.

Oaf Magoof: He judges people on the basis of their ability to get things done. He does not understand creative people and considers them a problem. He is a driver and favors the more dependable, practically oriented people.

Dizzi Busbee: He follows a close work schedule; is specific-work concerned. Everything for him has to apply to immediate work at hand, and he has little tolerance of, what he terms, the "harebrained" schemes.

Runnie Recluse: He sits isolated in his office and believes that every man should carry his own weight. He steers clear from meetings, from talking to his people, from any exchange of ideas. Although of no help to his creative people, he is, because of his complete withdrawal, least dangerous in stifling creative ideas.

Walter J. Friess, Supervisor of
Program Development,
AC Spark Plug Div., GM

the other hand he is separated from direct empirical relationship with observed phenomena by a fabulous amount of complex instrumentation.

Research which is merely the destruction of possibilities contains the meagerest kind of creativity.

Hire Creative People

It falls upon administration to insist upon selection procedures that will "screen in" genuinely creative personnel. Management should eliminate misleading selection methods and tests from screening procedures, and stop hiring people primarily on the basis of their ability to get along with others.

A timely and enlightened attitude toward this problem is expressed by E. Finley Carter, director of Stanford Research Institute:

> Preoccupation with the well adjusted personality is often over-emphasized. Let's acknowledge that brilliance is seldom well rounded. Rather than attempting to fill our laboratories with people who excel in personality tests and who demonstrate a healthy extroversion, we should welcome . . . people whose imbalances are, or can be, creative forces.

Summary

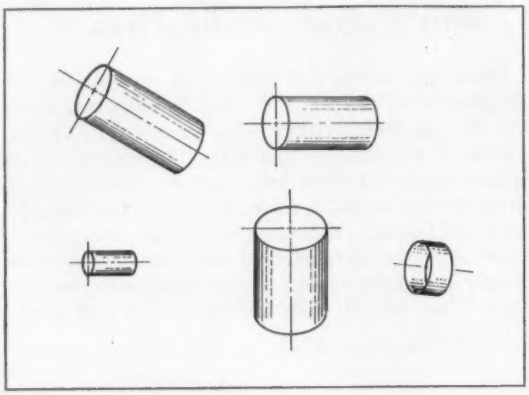
If all suggestions were followed, the resultant ideal climate would be one which:

- Allows more freedom in work milieu . . . is permissive and encourages creative effort . . . has freedom from restrictive objectives . . . provides flexible assignments . . . makes time available to think and experiment . . . minimizes deadline pressures . . . relaxes the rules of discipline and order . . . has semiflexible working hours . . . provides release from the inhibiting influences imposed by the usual "organization."
- Breaks down technical specialization barriers.
- Gives freedom to imagine or produce or experiment with ideas which may seem impractical at first glance . . . gives opportunity for variety of experience and change . . . has a wide range of challenging problems . . . gives a chance to try out ideas without prejudicial criticism.
- Treats each individual as a person of worth and with thoughtful understanding.
- Gives individual recognition over team competition, that is, identifies the individual as a member of a group rather than emphasizing the group of which he is a member.
- Provides constant stimulation by contacts outside the immediate field of the creative person.
- Provides security from financial failure due to failure of ideas.
- Provides adequate, modern equipment for experimentation . . . provides technical aids. Has quiet location for offices.

Tips and Techniques

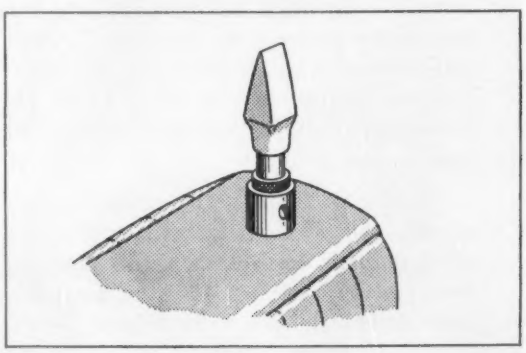
LeRoy Ellipses

The normal use of the LeRoy letter adapter is to "stretch" characters vertically. Another practical use is in inking ellipses on a drawing. Ellipse size is governed by the size of template used. The letter adapter is set for the desired height and the template is positioned at the proper angle. The ellipse is then inked in normal fashion.—F. H. HADFIELD, *Stromberg-Carlson Co., Div. of General Dynamics Corp., Rochester, N. Y.*



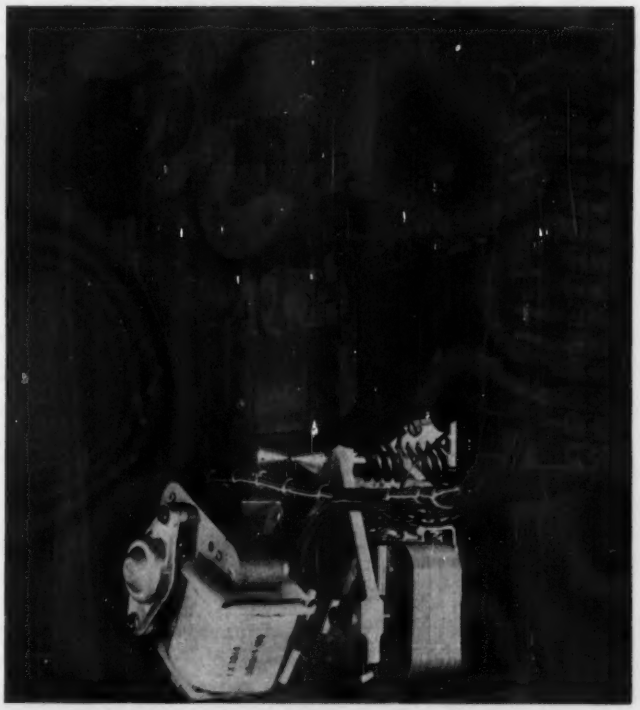
Increasing Eraser Effectiveness

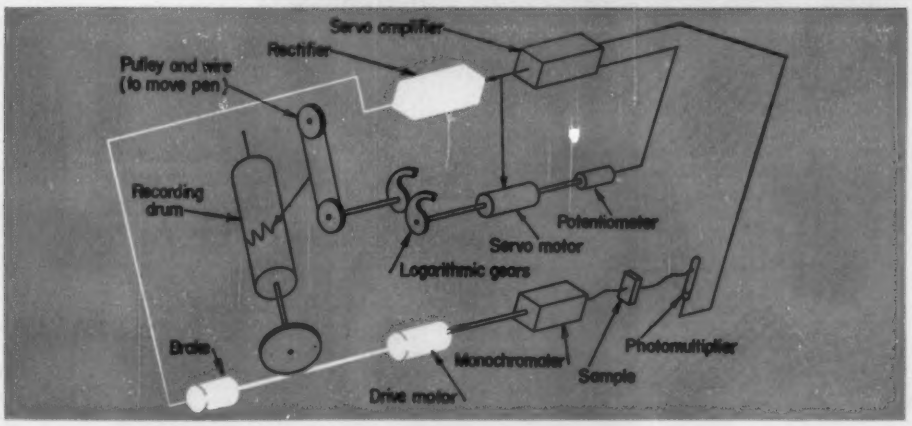
An electric eraser covers more ground when a standard pencil eraser is added as shown. To make a snug fit, the tightening collar is moved down on the shaft, the standard eraser plug is left in position, and the pencil eraser is slipped over the jaws on the shaft. The added eraser is then trimmed with a file and is ready for use.—ERNST E. KREMEYER, *design engineer, Anderson Bros. Mfg. Co., Rockford, Ill.*



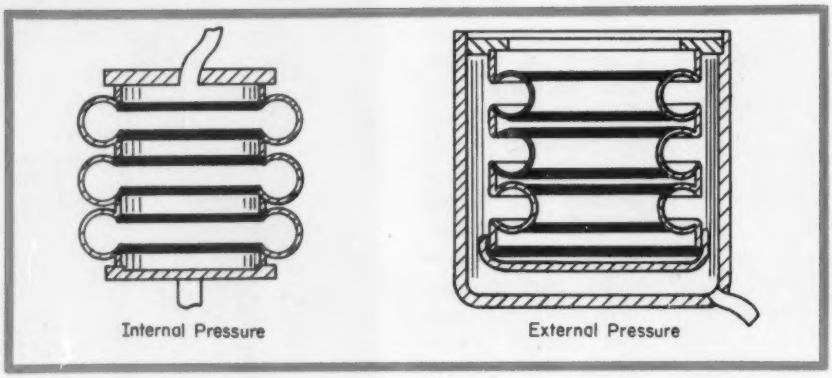
scanning the field for *ideas*

Opposed motors produce an output speed proportional to intensity of variable being measured. The signal which drives the recording pen is also converted by a rectifier and forced through an ac induction motor used as a brake. This arrangement produces a rapid scan through simple spectra, but reduces drum speed during complex spectra. Principle employed in spectrophotometer developed by Bausch and Lomb Optical Co., Rochester, N. Y.

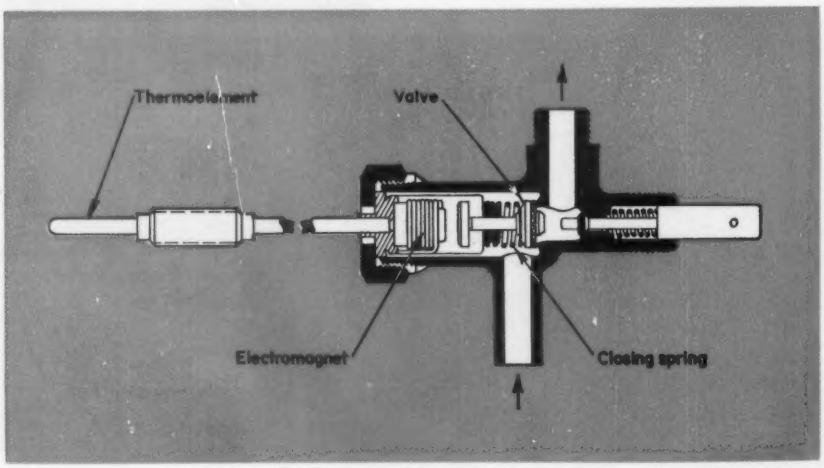




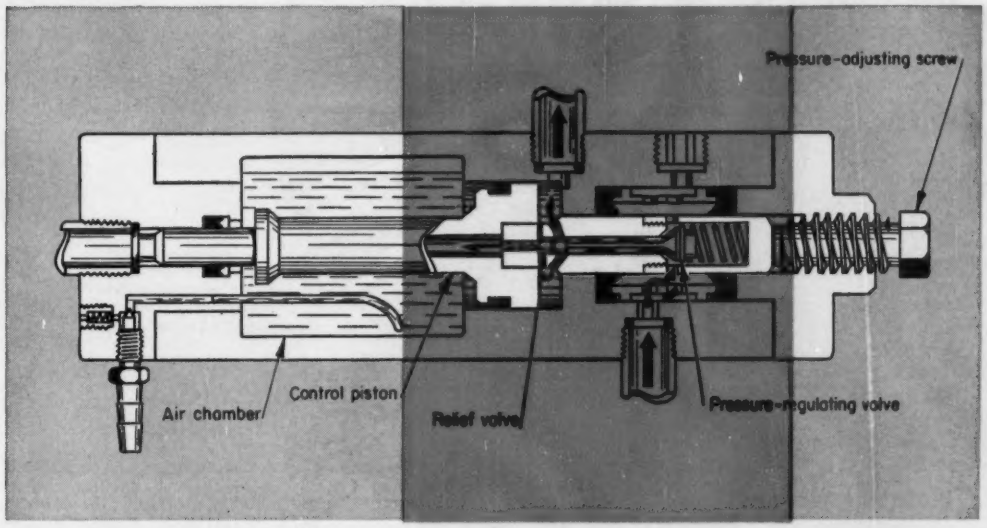
Omega-shaped contour of bellows helps equalize stress distribution during actuation. The design produces high total deflection with low convolution deflection. Force or deflection output is nearly linear. Principle employed in bellows developed by B. F. Goodrich Co., Akron.

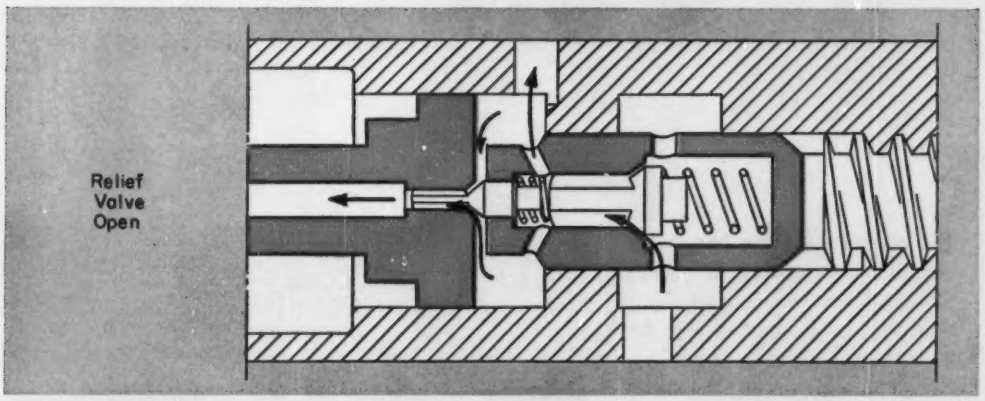


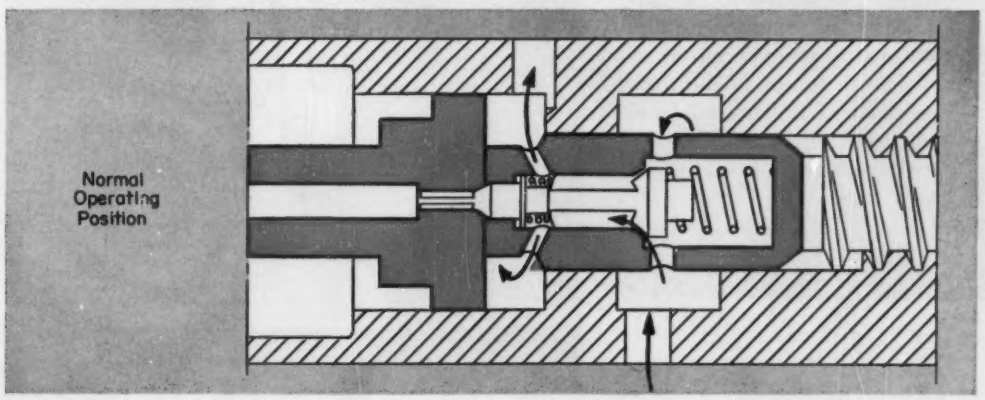
Self-powered circuit provides sufficient current to operate a solenoid in a gas-fuel safety valve. When the flame fails, the electric current from the thermoelectric element ceases, and the electromagnet is no longer energized. A preloaded spring then forces the valve closed. Principle employed in a gas range developed by Junkers & Co., Wernau/Neckar, Germany.

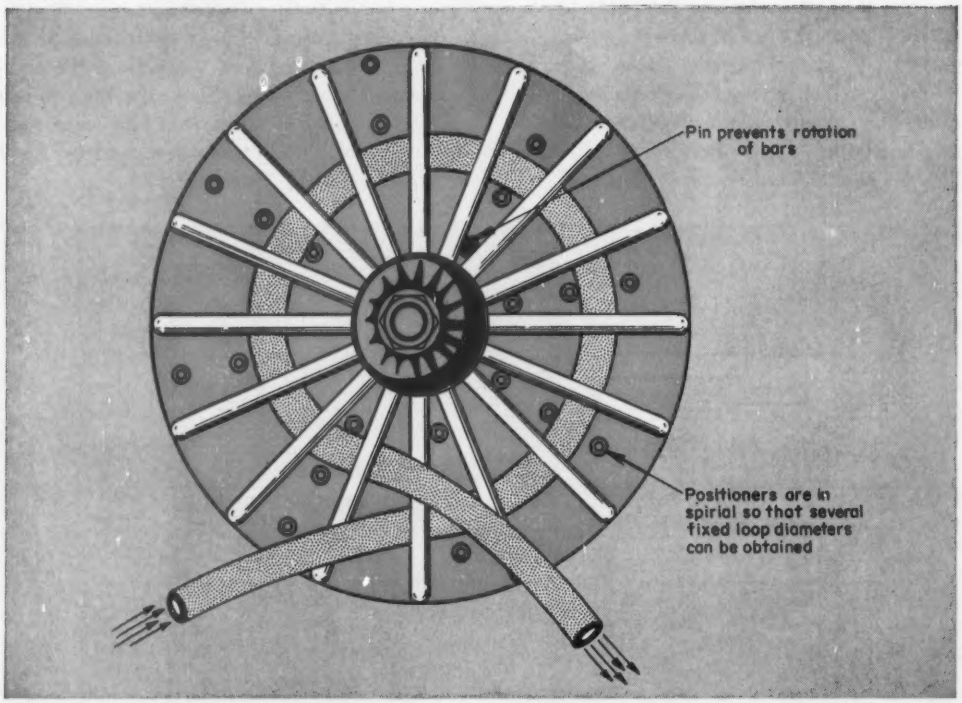


Relief plus regulation of pressure is provided by a dual-function piston. In normal operation, the pneumatically-loaded piston senses the output pressure to position the pressure-regulating valve. Pressure produced by leakage past this valve, or by feedback from a mechanical overload on the connected actuator, moves the piston away from the end of the regulating valve. Thus, the high pressure is vented to the sump. Principle employed in pressure-regulating valve developed by AB Alpha, Sundbyberg, Sweden.



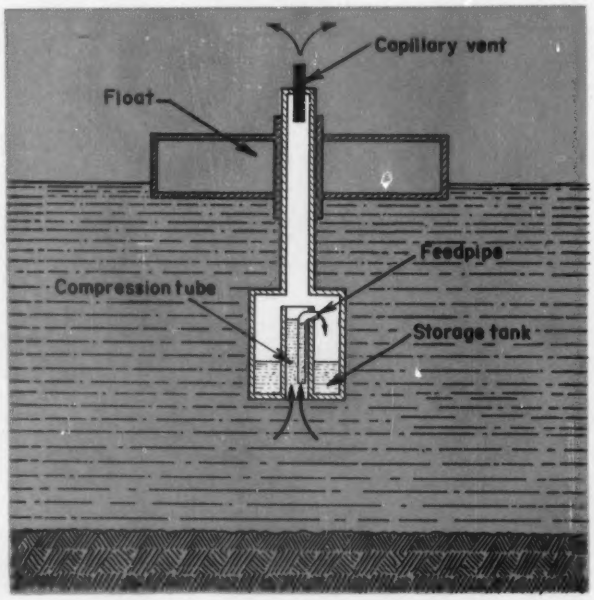




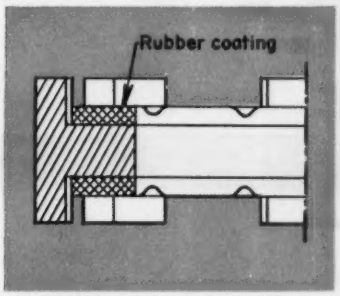


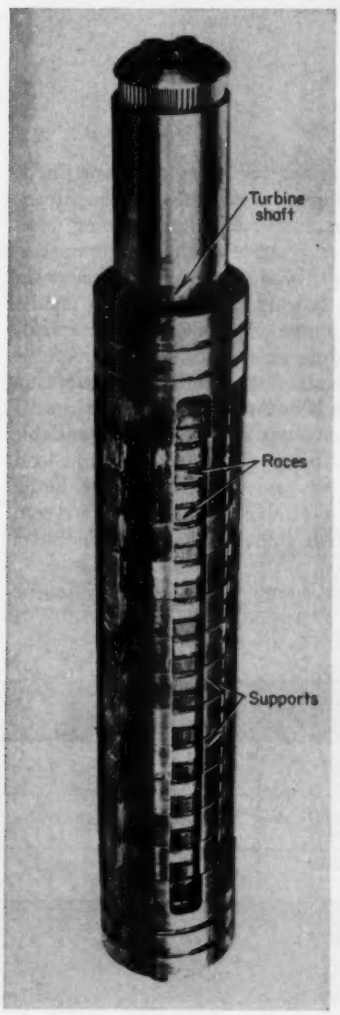
Nutating spokes pump liquids, gases, or slurries by progressively pinching a loop of flexible tubing. The finger-like motion, produced by bent shaft and ball-bearing arrangement, progressively pinches the tubing, pushing the fluid ahead of the point of contact. Principle employed in pump developed by Sigmamotor Inc., Middleport, N. Y.

Slow-rate collector samples fluid flow during an extended time period. Static head of the fluid stream is opposed by the air trapped in the tank. Controlled venting of the air reduces entering rate of the liquid. The feed pipe and compression tube arrangement prevents mixing of sample with passing fluid. Principle employed in sampler developed by Frieseke & Hoepfner GmbH, Erlangen-Bruck, Germany.

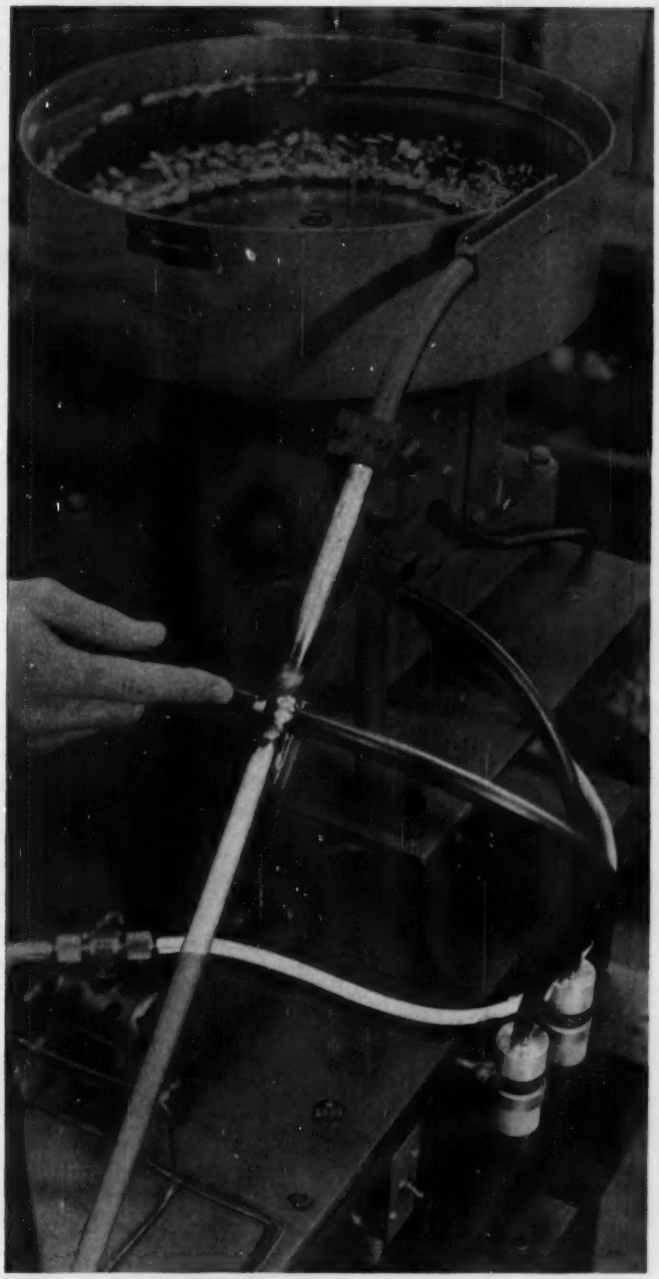


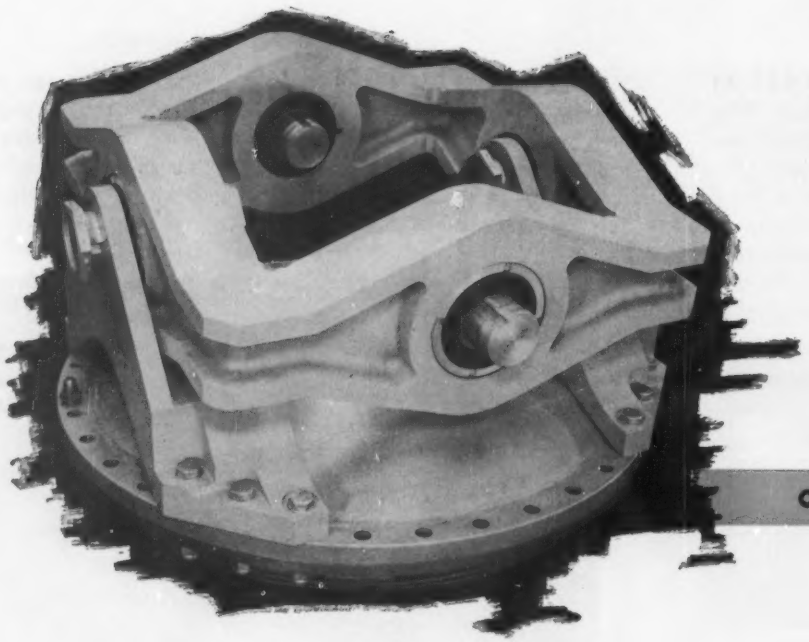
Rubber-coated collar bearings permit slight deformation to equalize thrust load among multiple assemblies. Otherwise, build-up of tolerance might cause races to be loaded unequally. Principle employed in pump developed by Mannesmann-Trauzl AG, Vienna, Austria.





Sound pipes guide sensing "beams" of ultrasonic detector. Thus, a concealed or remote installation can be used for the transducers of a noncontacting sensing and switching system which uses ultrasonic energy for its beam. Principle employed in ultrasonic detector developed by Delavan Mfg. Co., West Des Moines, Iowa.





High-

C. M. DANIELS, Supervisor

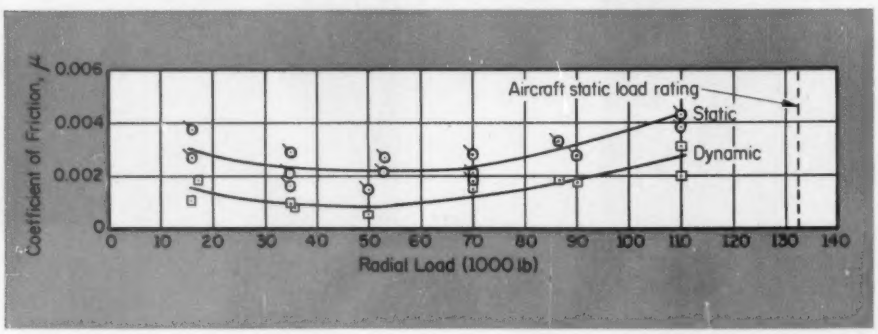
LIMITING loads that bearings can carry in oscillatory motion have not been thoroughly explored — for instance, when bearing loads must be as great as possible and friction must be relatively low. Such conditions prevail, for example, in the gimbal bearings of rockets. Bearing life is measured in minutes. Weight restrictions make the extremes in loading paramount.

Fig. 1 is a typical rocket gimbal. The unusual features about the bearings of this design are: 1. The angular motions are oscillatory and variable, with 15 degrees as the maximum. 2. The unit loads are high, 16,500 psi and greater. 3. The design life is short. Other desirable characteristics are compactness, low friction, reliability, and little or no maintenance.

To get data for design purposes, both journal

Fig. 1—High-load journal bearings in square-ring rocket-engine gimbal.

Fig. 2 — Friction coefficients for a full-complement, center-guided needle bearing, without inner race.



Load Oscillating Bearings

Load and friction design data for abnormal conditions

Rocketdyne, Div. of North American Aviation Inc., Canoga Park, Calif.

bearings and antifriction bearings were tested under heavy oscillatory loads. Representative data from the tests are presented here.

Journal bearings were investigated first because antifriction bearings were regarded as too bulky and heavy. Later, the thinking changed: Complete gimbal assemblies using antifriction bearings were designed, built, tested on engines, and proved reliable. True to expectations, the antifriction bearings reduced the frictional resistance by 80 per cent over journal bearings.

Journal Bearings: All the journals and the bearings were made from chrome-moly steel 4340. The bearing material was heat-treated to 200,000 to 220,000 psi; the journal material was heat-treated to 160,000 to 180,000 psi. The majority of the journals were chrome plated. The exceptions in plating, for example, the electroless nickel plating, are indicated in Table 1.

All the journal-bearing units had shafts 2.75 to 3.00 in. in diam. Cycling frequency was 60 cpm, and amplitude of the oscillations was 14 degrees.

Table 1—Plain Journal Bearings

(Basic data: 4340 steel. Bearing heat-treated to 200,000 to 220,000 psi; journal, to 160,000 to 180,000 psi, chrome plated)

Modifications in Plating and in Use of MoS_2 Solid Film, Dry Lubricant	Additional Grease Lubricant	Frictional Data — Static — Load (psi)	Static — Coef, μ	Dynamic — Load (psi)	Dynamic — Coef, μ	Test Machine Used
None	MIL-G-3278	16,500 to 30,500	0.19 to 0.11	16,500 to 30,500	0.105 to 0.08	Nut-cracker
None	MIL-G-7118	16,500 to 30,500	0.115 to 0.06	16,500 to 30,500	0.11 to 0.07	Nut-cracker
None	None	16,500 to 30,500	0.26 to 0.215	16,500 to 30,500	0.22 to 0.17	Nut-cracker
MoS_2 omitted from both bearing and journal	MIL-G-7118	16,500	0.11 to 0.21	16,500	0.02 to 0.20	Nut-cracker
MoS_2 on bearing but not on the journal	MIL-G-7118	16,500 to 30,500	0.09 to 0.06	16,500 to 30,500	0.060 to 0.055	Nut-cracker
Electroless nickel-plated journal	MIL-G-7118	.....	....	16,500 after 1500 cycles	0.023 0.075	Swinging head
Hard chrome plated journal	MIL-G-7118	.....	....	16,500 after 500 cycles	0.045 0.085	Swinging head
None	MIL-G-7118	.....	....	16,500 after 1250 cycles	0.040 0.080	Swinging head
Electrolized (thin, dense chromium plating on both bearing and journal)	MIL-G-7118	.....	....	16,500 after 200 cycles	0.048 0.053	Swinging head

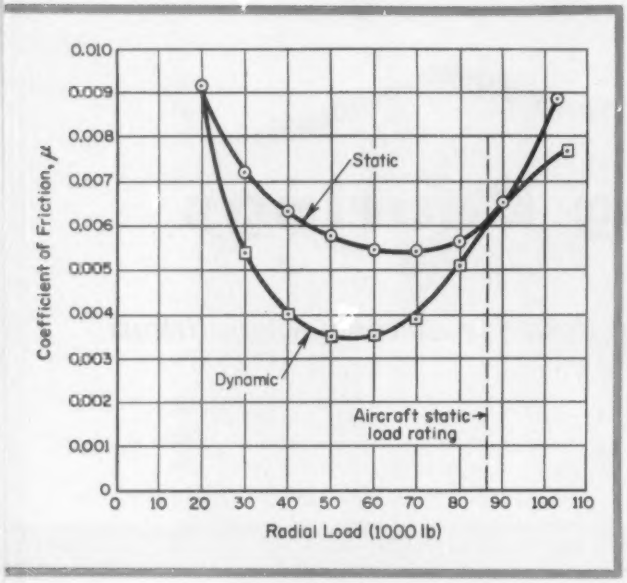


Fig. 3—Friction coefficients for a caged needle bearing without inner race.

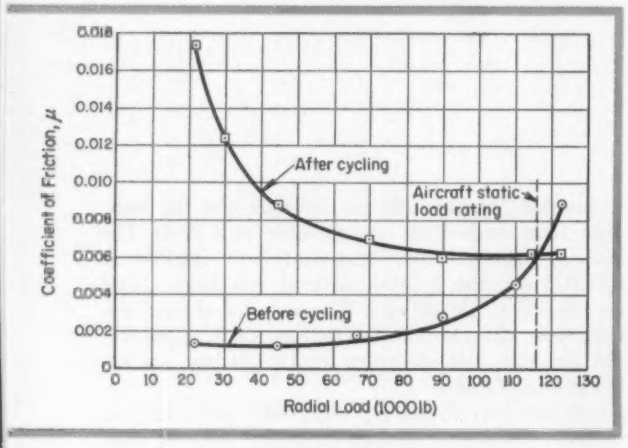


Fig. 4—Dynamic friction coefficients for a full-complement needle bearing without inner race.

Much has been written about the frictional properties of various molybdenum-disulfide dry lubricants. Most research, however, has been based on data gathered in laboratory tests on small-scale samples under linear sliding motion or rotary motion and under relatively low total loads.

Verification of the test data under extreme loading seemed necessary. The data presented here are based upon full scale models loaded to "in-service" rated loads.

In most combinations of bearing and journal, both bearing surfaces were coated with a thermosetting, molybdenum-disulfide, solid film, dry lubricant. The few exceptions are noted in Table 1. Additional lubrication was also supplied by grease.

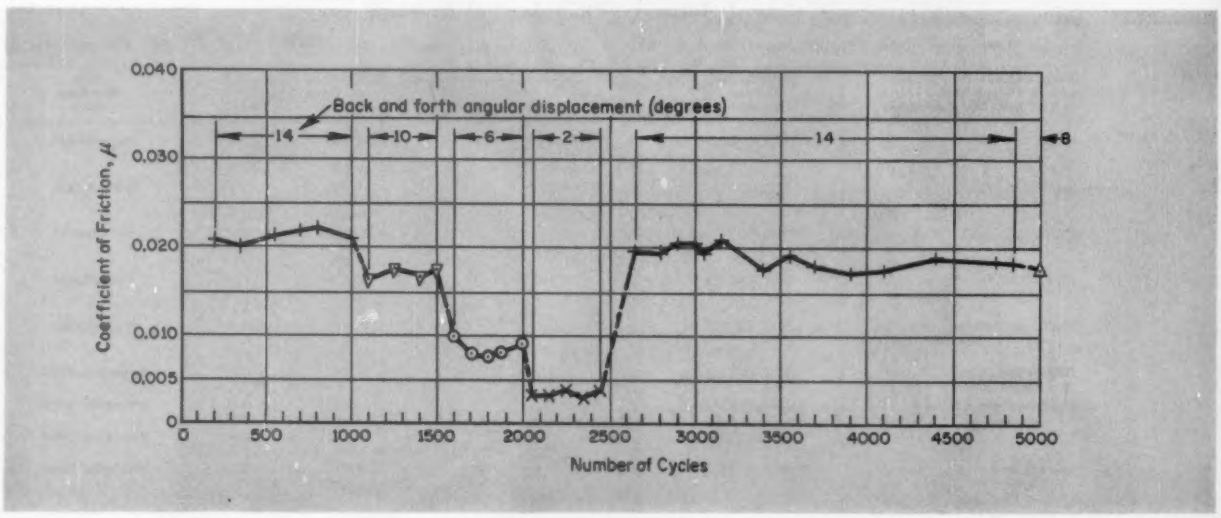
The combination of lubricants resulted in a dynamic coefficient of friction on the order of 0.08 over the life of the bearing assemblies. The many tests show that journal bearings will consistently function properly under unit loadings from 16,500 to 30,500 psi.

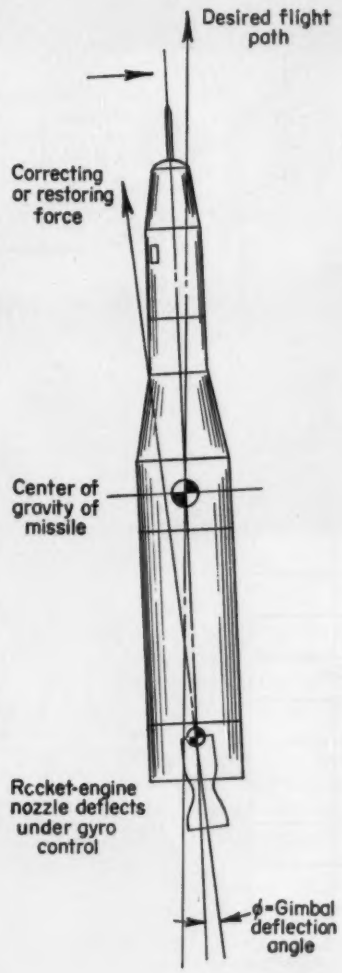
The MIL-G-7118 is a diester type synthetic grease, Table 1. In combination with the molybdenum-disulfide, solid-film, dry lubricant on both the bearing and the journal surfaces, it provided the longest life and the lowest frictional forces of all the combinations. In every test involving dry lubricant, the friction coefficients decreased with an increase in unit loading. This agrees with the test results reported by previous investigators.[1, 2, 3, 4]

Antifriction Bearings: Friction in antifriction bearings has been the subject of hundreds of tests by many investigators. While the test results have not always been in full agreement, they indicate clearly that: 1. Frictional torque is low. 2. It is difficult to determine experimentally. 3. Test results vary with differences in bearing construction, such as race, cage, and rolling element design, as well as with variations in bearing lubrication. Also, both static and dynamic friction are at least an order

[1]References are tabulated at end of article.

Fig. 5—Variation of the coefficient of friction with the number of cycles and amplitude of cycling in a full-complement needle bearing with inner race.




Desired flight path
Correcting or restoring force
Center of gravity of missile
Rocket-engine nozzle deflects under gyro control
ϕ=Gimbal deflection angle

Gimbal Development for Rocket Motors

The first high-thrust, liquid-propellant, gimballed rocket engine in the free world was fired by Rocketdyne in 1954. The gimbal, itself mounted to the top or head end of the engine's thrust nozzle, sustained a thrust in excess of 100,000 lb.

By present standards, the gimbal used on that engine was crude and heavy. It was a square ring, Fig. 1, of 4340 steel using spherical, self-aligning, plain journal bearings. The chief reason for selecting this design was that it allowed the routing of one of the propellant feed ducts through its center and thus gave it direct entrance into the top of the thrust chamber.

It soon became apparent, however, that the weight of this unit was not compatible with the over-all engine weight. The high bending moment caused by the wide displacement of the load-reaction points required very heavy beam cross sections to resist excessive deflections.

The engines for the Viking and the Vanguard first-stage rockets also utilized the circular-ring type of gimbal. Since their thrust levels were relatively low, the disadvantages of this design were probably offset by the advantage of having one of the propellant feed lines pass through the gimbal center.

Spherical gimbals have been used in second-stage vehicles. The major drawback of this type is its inability to absorb high twist loads about the rocket-nozzle longitudinal center line.

Design studies for a replacement of the square-ring gimbal culminated in a cross-shafted gimbal. This design was essentially a shaft split in two along an axial centerline plane and one half rotated 90 deg with respect to the other. A pillow block covered each half shaft. This basic design with refinements is used on the Jupiter, Thor, and Atlas engines today.

Table 2—Needle Bearings

Fig. No.	Needle Bearing Type (no inner race)	ID (in.)	Static Load Rating (lb)	Steel Shaft Material and Hardness	Grease Lubricant	Test Machine
2	Full-complement with center guide	2.75	132,000	52100 Rockwell C60	MIL-G-7118	Nut-cracker
3	Caged	2.75	86,000	52100 Rockwell C60	MIL-G-7118	Nut-cracker
4	Full-complement	2.75	116,000	4620 carburized Rockwell C60	MIL-G-7118	Nut-cracker

Table 3—Friction Coefficients of Roller Bearings

Fig. No.	Types of Bearing With Inner Race	ID (in.)	Static Load Rating (lb)	Grease Lubricant	Load (lb)	Friction Coef μ	Test Machine
None	Concave-roller, self-aligning spherical	2.310	38,100	MIL-G-3278	20,000 to 40,000	0.014 to 0.016	Nut-cracker
5	Full-complement needle	5.000	175,100	MIL-G-3278	113,000	0.022	Swinging head
6	Caged roller	6.500	396,000	Molub-Alloy*	125,000	0.0015	Swinging head
7	Full-complement needle	2.250	94,600	MIL-G-3278	94,600	0.002 to 0.016	Swinging head

*Imperial Oil & Grease Co. Inc.

of magnitude lower in antifriction bearings than in plain journal bearings.

The following observations were made concerning needle and roller bearings based on design analysis and testing for gimbal applications:

1. Design analysis and test results show that where radial and thrust loads must be carried by a bearing, a lighter and more compact installation can be had by using a needle bearing for carrying the radial load and a needle or ball thrust bearing for carrying the thrust load. A roller bearing capable of accommodating both types of load, such as the concave or tapered-roller type, compromises its load-carrying ability in each direction and consequently requires a larger installation package than two individual load-carrying bearings.
2. Standard catalog-type needle bearings can be used at loads up to their static aircraft ratings under small-angle and low-frequency oscillating motion for the short periods peculiar to rocket engines and missiles.
3. A full-complement needle bearing has greater load-carrying ability for a given size than a caged bearing. Its coefficient of friction is lower under oscillatory motion, probably because it has more rollers carrying the load.
4. Life expectancy of needle bearings is greater than that of all of the metal journal-type bearings in similar applications, and less maintenance is required.
5. Coefficient of friction at low loads has a tendency to be high. At about half the rated static load it becomes a minimum value, rising again as the static rated load is approached. This phenomenon was observed by Palmgren[5] in ball and roller bearings, although his tests were run at loads much below the static capacity of the bearings.

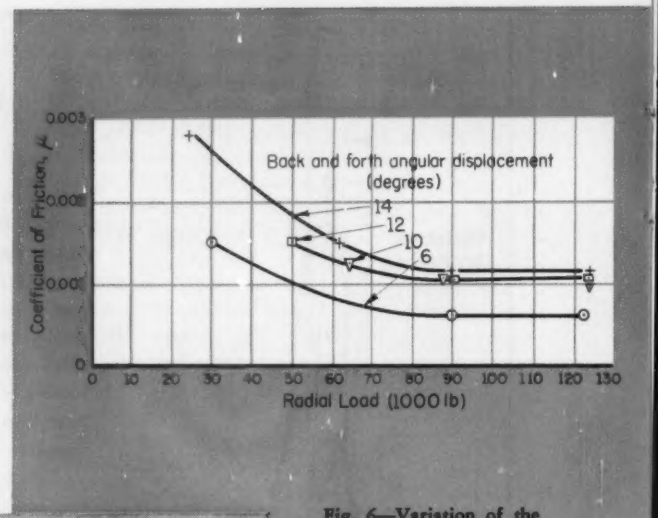


Fig. 6—Variation of the coefficient of friction with amplitude of cycling in a caged roller bearing with inner race.

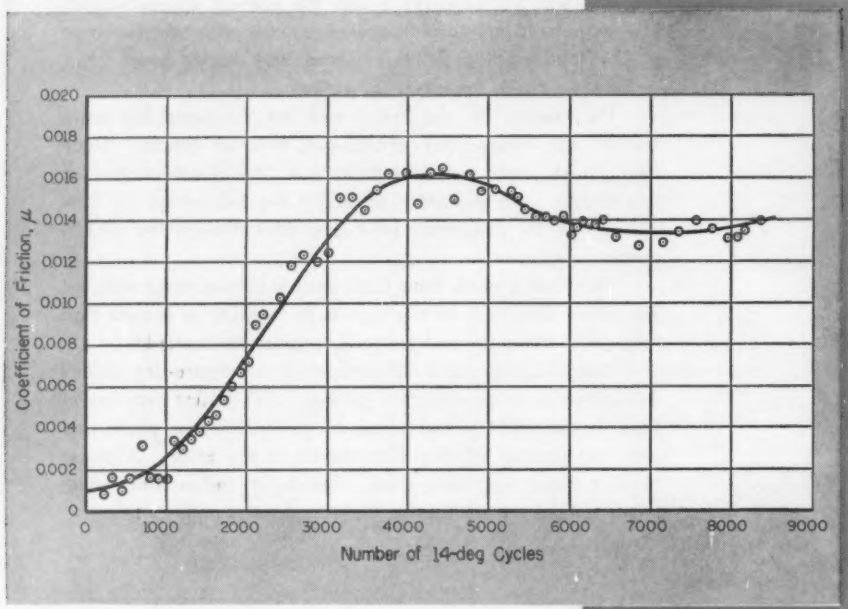
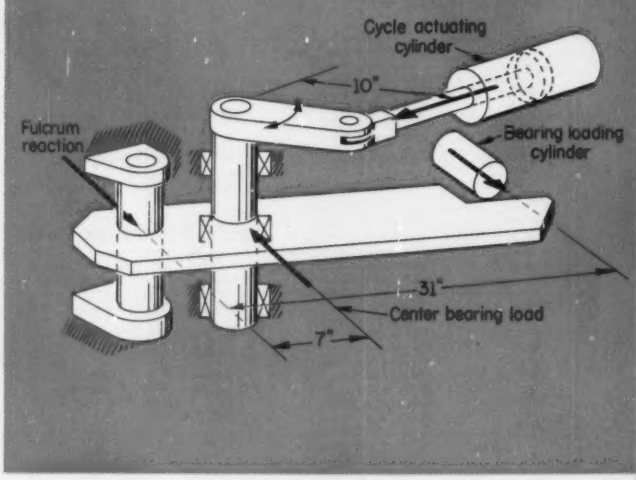


Fig. 7—Running friction versus life for a full-complement needle bearing with inner race.

Fig. 8 — Bearing-tester loading.



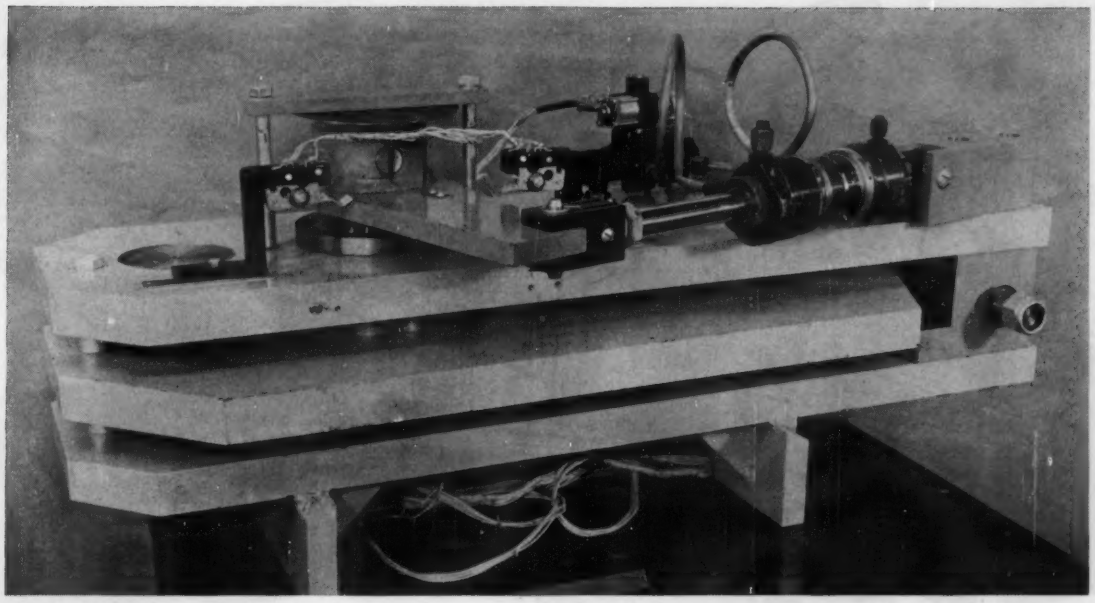


Fig. 9—Nutcracker test machine

Fig. 2 and 3 are typical of the manner in which the friction coefficients fall and rise with load. The points that establish the static curve were obtained before cycling; those for the dynamic curve at the beginning of cycling.

What can happen to the friction coefficients after cycling is illustrated by Fig. 4. The two curves differ by one-half hour of cycling at 72 cpm under 110,750 lb load. A cycle represents rotation through 14 deg and return.

Fig. 2, 3, and 4 show that full-complement needle bearings have lower coefficients of friction than caged types. A theory can be postulated from these observations: For a given applied load, the unit loading per needle is lower for the full-complement types than for the caged type since they have more needles in the load-carrying area. The full-complement types are therefore working in the lower portions of the coefficient versus load curves while the caged types are working in the right-hand or high-coefficient portion of the curve.

Oscillation angle has a noteworthy influence upon the friction coefficient, Fig. 5 and 6. One possible explanation of the larger coefficients of friction with the increase in oscillation angles is the cocking or skewing of the needles and the counter-rotational friction in the full-complement bearings.

This increase in friction for the caged bearing is less than that for the full-complement bearing over the range of angles tested. For the equivalent in load-carrying capacity, however, the caged bearing must be larger than the full-complement bearing to offset the fewer number of needles.

Fig. 7 illustrates a marked build-up in the running coefficient of friction when a full-complement needle bearing is subjected to cycling at aircraft static load rating, Table 3. The angular displacement for the cycle was 14 degrees; the frequency rate was 60 cpm. For 1000 cycles the friction coefficient remained less than 0.0025. For 5000 cycles it was about 0.0156. More than 8000 cycles were sustained by the bearing before failure.

Testing Procedure: The bearings were tested in two machines especially designed for the purpose. They are identified in Tables 2 and 3 as the "nutcracker" and the "swinging head." A brief description of the former, Fig. 8 and 9, may be helpful toward visualizing the nature and the severity of the cycling tests.

Three bearings were subjected to test loads and cycling simultaneously, each bearing being retained in a deep-web, plate beam. A fulcrum shaft was located parallel to and outside of the test shaft. The load was applied to the center plate beam by a hydraulic actuator. The outer two bearings and their plate beams provided the reaction loads to the center bearing load.

The test shaft was then oscillated back and forth with a crank arm by a hydraulic actuator linkage at the desired speed and deflection angle. Pressure pickups in the actuator recorded pressures during oscillation. From these pressures and the geometry of the test machine, torque values and the coefficients of friction were computed. The coefficients plotted from the data gathered with this machine represent the average values for the three test bearings, the center bearing being loaded to twice the load of the outer two. The load plotted along the abscissa is the radial load upon the center bearing.

References

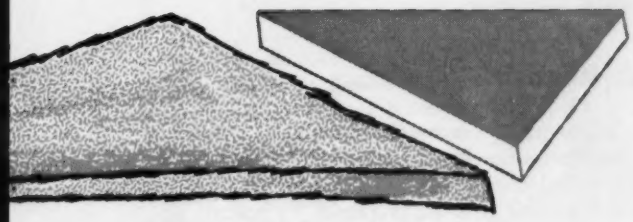
1. R. E. Crump—"Factors Influencing Wear and Friction of Solid Film Lubricants," *Product Engineering*, Vol. 28, No. 15, Mid-Oct., 1957, pp. C24-C27.
2. M. H. Weisman—"Application of Dry Film Lubricants in Plain Bearings," MACHINE DESIGN, Feb. 6, 1958, pp. 107-110.
3. R. E. Crump—"Solid Film Dry Lubricants," *Product Engineering*, Feb., 1956.
4. "Molybdenum-Disulfide as a Lubricant," Climax Molybdenum Co., 500 Fifth Ave., New York (A collection of excerpts from eleven technical papers on this subject).
5. A. Palmgren—*Ball and Roller Bearing Engineering*, S. H. Burbank & Co. Inc., Philadelphia, 1945, p. 38.

Designing with Vinyls

C. W. BULKLEY
Technical Service
Vinyl Resins and Compounds
Monsanto Chemical Co.
Springfield, Mass.

Vinyls appear in so many forms that they are often difficult to recognize. Like the chameleon, vinyl seems to be adaptable to the requirements of its surroundings. It can be formed into almost any shape, hard or soft, flexible or rigid, smooth or rough, transparent or opaque, and in almost any color.

How can these variable characteristics and properties be used to best design advantage? This article, first of a three-part series, discusses factors involved in selecting and specifying vinyl materials. Subsequent parts cover mechanical properties, forms, and typical applications of vinyl compounds.



Part 1
Characteristics of Materials

WITH so many variations of vinyl chloride on the market, differing in one or more properties from one another, it is difficult to compare charts of various plastics and know just what vinyl has its properties listed. What *are* the inherent qualities of this material with its wide range of forms and formulas to choose from?

The answer, of course, is not a confining list of properties; the most appropriate single-word description of vinyls is "versatile." This versatility is the reason for the rapid and continuing growth of this branch of the plastics family. This growth, in turn, has permitted a corresponding drop in price of vinyls, Fig. 1, in the past twenty years.

Vinyl Characteristics

As durable, colorful, easily cleaned coverings or trim, vinyls find a place in many products. Handle grips of floor-waxing machines, vacuum cleaners, golf-bag carts, and bicycles resist dirt, grease, and perspiration, as do door-lock pushbuttons for automobiles and color-coded coatings for control levers.

Stretchability of flexible vinyls permits removal from molds with heavy undercuts for snap-on fits on the end-use product. Extruded shapes are designed to snap or slide into grooves. One patented design works like a zipper, and is used not only for briefcase envelopes, but also to encase bunched wiring or pipe insulation.

Resistance wire for heating elements is insulated with high-temperature (105 C rated) vinyl compound. Machinery mounts and shock absorbers take advantage of the resilience and vibration-damping action of vinyl elastomers. Vinyls are not aged and cracked by ozone, nor do they oxidize and deteriorate during storage.

While vinyl is well known for its insulating characteristics, it also plays a diametrically-opposite role when compounded to conduct electrical current and dissipate static electricity.

Unplasticized resins of vinyl chloride and its copolymers give certain basic characteristics to products made from them, such as flame resistance superior to many other thermoplastics, electrical insulation of a high order, and chemical resistance to most acids, caustics, and solvents of the nonaromatic type.

However, the addition of various compatible plasticizers gives vinyl chloride its greatest single asset: Its tailorability to fit jobs demanding varying degrees of flexibility and softness. Thus, not only can the composition, structure, and molecular weight of the resin itself be varied, but each variant can be mod-

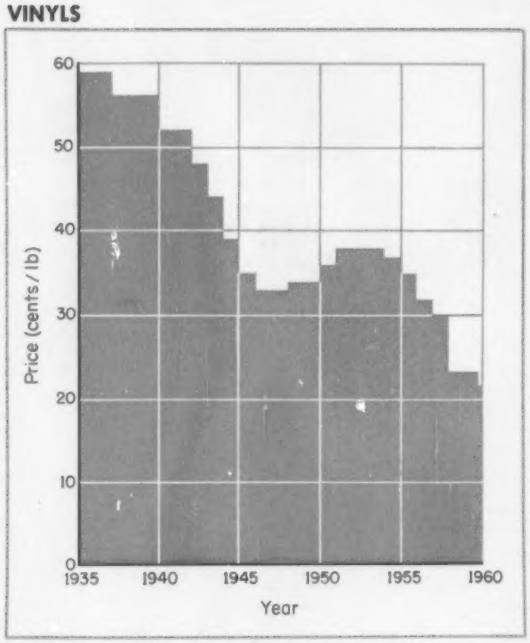


Fig. 1—Price history of polyvinyl-chloride resins.

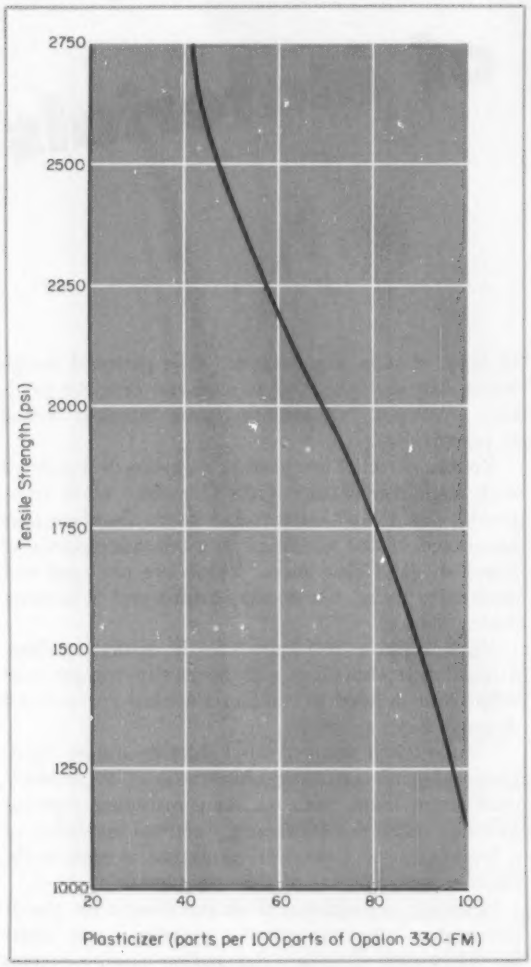


Fig. 2—Effect of plasticizer on tensile strength of vinyl-chloride compound. Basic formulation: Opalon 330-FM, 100 parts; filler, 25 parts; stabilizer, 2 parts.

ified further by compounding with plasticizers, fillers, and other ingredients.

Basic Materials

How are these compounds formulated, and what are the effects of each type of ingredient? Most commercial vinyl compounds are a compromise toward the best possible over-all properties for specific applications. For example, some chemical resistance is traded for flexibility, some resistance to heat for cold-weather flexibility, etc.

Resin is the polymerized* strength-giving member that holds the compound together, whether in rigid or flexible form. Higher molecular weights generally give superior properties, but they limit processability in many applications because of the associated stiffness of flow; optimum properties are seldom obtained with poor processing.

Copolymers are made by simultaneously reacting two monomers, such as vinyl chloride and vinyl acetate, to form molecular chains containing both materials. Such a product usually processes more easily than straight PVC (polyvinyl chloride), but its chemical resistance, electrical properties, and stability towards heat and light tend to be slightly inferior.

However, since many applications do not require more of these attributes than such copolymers can furnish, the improved processability is often adequate justification for a compromise. For example, the high-filler tolerance of vinyl chloride-vinyl acetate copolymer qualifies it for the binder resin of vinyl-asbestos floor tile. This product is similar to asphalt tile, but is more durable and grease resistant.

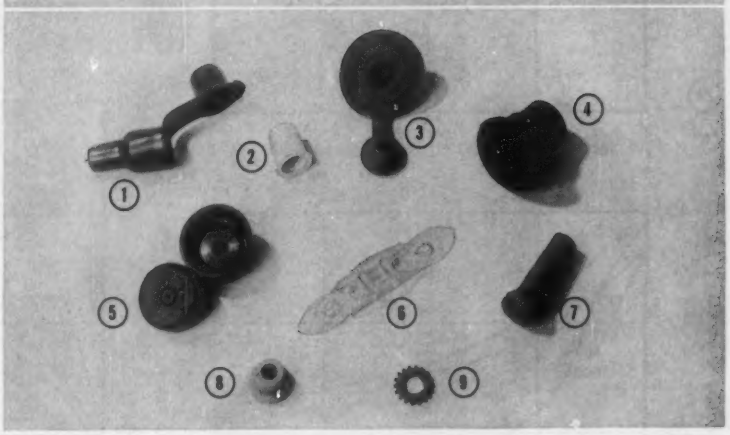
Good flow characteristics and microscopically correct mold reproduction make similar types of resin excellent choices for high-quality stereophonic phonograph records.

Further resin variations are possible through terpolymers, made by reacting together three different monomers, or by mixing polymers and copolymers at later stages of processing, to form "polyblends." For example, styrene-acrylonitrile (SAN) can be blended with PVC to aid processing; chlorinated polyethylene is mixed with PVC to improve dielectric properties and widen the range of operating temperatures for rigid PVC (−40 to 85 C); nitrile rubber (butadiene-acrylonitrile) is blended with PVC to formulate high-impact extrusion compounds.

Stabilizers are required whether vinyl chloride is rigid or flexible, and whether used as a monomer, copolymer, or polyblend. At high temperatures, there is a tendency for chlorine to split from the molecular chain and join with hydrogen to form hydrochloric acid. This reaction can be rapid at process temperatures of about 400 F. The function of a stabilizer is to delay this reaction. Effectiveness

*Polymerization is a chemical reaction carried out under controlled temperature and pressure. Vinyl chloride "monomer," a liquid under pressure to keep it from evaporating, consists of single-unit molecules which hook together during the process to form long chains, some with branches. Weight, length, and shape of these synthesized macromolecules affect properties of resultant materials.

Appliances use vinyls in many ways: The air-conditioner power cord, left, has plug molded securely over insulation of wire; bumper strip and vacuum-cleaner parts, center, show how undercuts can be molded for snap-on fits and for flexibility; gasket, right, is used in food-mixer assembly.



Small parts show the versatility of vinyl at a glance. Parts are: 1. Splice cap. 2. Threaded tube cap 3. Valve for inflatables 4. Ignition distributor nipple 5. Flow-control device 6. Fastening device 7. Automobile door-lock button 8. Boss, upset from extruded rigid tube 9. Gear, stamped from extruded rigid sheet.

depends upon the type and concentration of stabilizer used.

Since the most effective types are also the most expensive, economics have a bearing on formulation in this regard. Because it is gradually used up in doing its work, no stabilizer is completely effective at very high temperatures for extended periods of time. Vinyl compounds thus have a "heat life," as well as an "ultraviolet light-exposure life." In the latter case, special stabilizers and UV screening ingredients are used when economically justified.

Plasticizers exert a solvating action on vinyl resins, causing them to swell and soften but not to liquefy. Plasticizer molecules work their way beween resin molecular chains and permit them to slide past each other, making the product flexible. The more the plasticizer, the greater the flexibility, but the less the tensile strength, Fig. 2. Plasticizers vary in their efficiencies and in their degree of permanence:

1. Compatible plasticizers do not come to the surface and make the product tacky.
2. Plasticizers with low volatility do not readily leave the compound, even at elevated temperatures.
3. Nonmigrating plasticizers do not leave the compound to attack susceptible materials with which regular contact may be designed, such as lacquers, varnishes, styrene, or rubber.

Plasticizers range in cost from $.03 to $.80 per lb, and the quality varies accordingly. This does not mean, however, that the most expensive is justified, or even will do the best job in every application. Compromises in plasticizer selection are frequently required, since each plasticizer has certain disadvantages along with its advantages.

Fillers are incorporated in vinyl compounds chiefly to reduce cost. Since physical strength is inversely proportional to concentration of filler, Fig. 3*a*, the amount used depends upon the desired cost/performance ratio for a particular design. Specific gravity, Fig. 3*b*, is the best single indicator of extent of loading.

Fillers reduce surface glossiness, and have a serious effect on reducing recovery from deformation. A properly made unfilled vinyl will recover almost 100 per cent of its original dimensions after being stressed 50 per cent, either in compression or tension.

Use of properly selected fillers is not to be frowned on however, since certain benefits do accrue from their use beside those of economic importance. For example, electrical insulation characteristics are improved by certain types of clay; surface appearance can be modified by fillers to give dry feel, lower coefficient of friction, or dull finish; stiffness and hardness of the product can be increased, Fig. 3*c* and 3*d*.

Pigments are usually used, rather than dyes, for coloring vinyls. These are chosen with regard to heat and light stability as well as resistance to rub-off. Filler systems also have a pigmenting effect and must be considered as part of any color system.

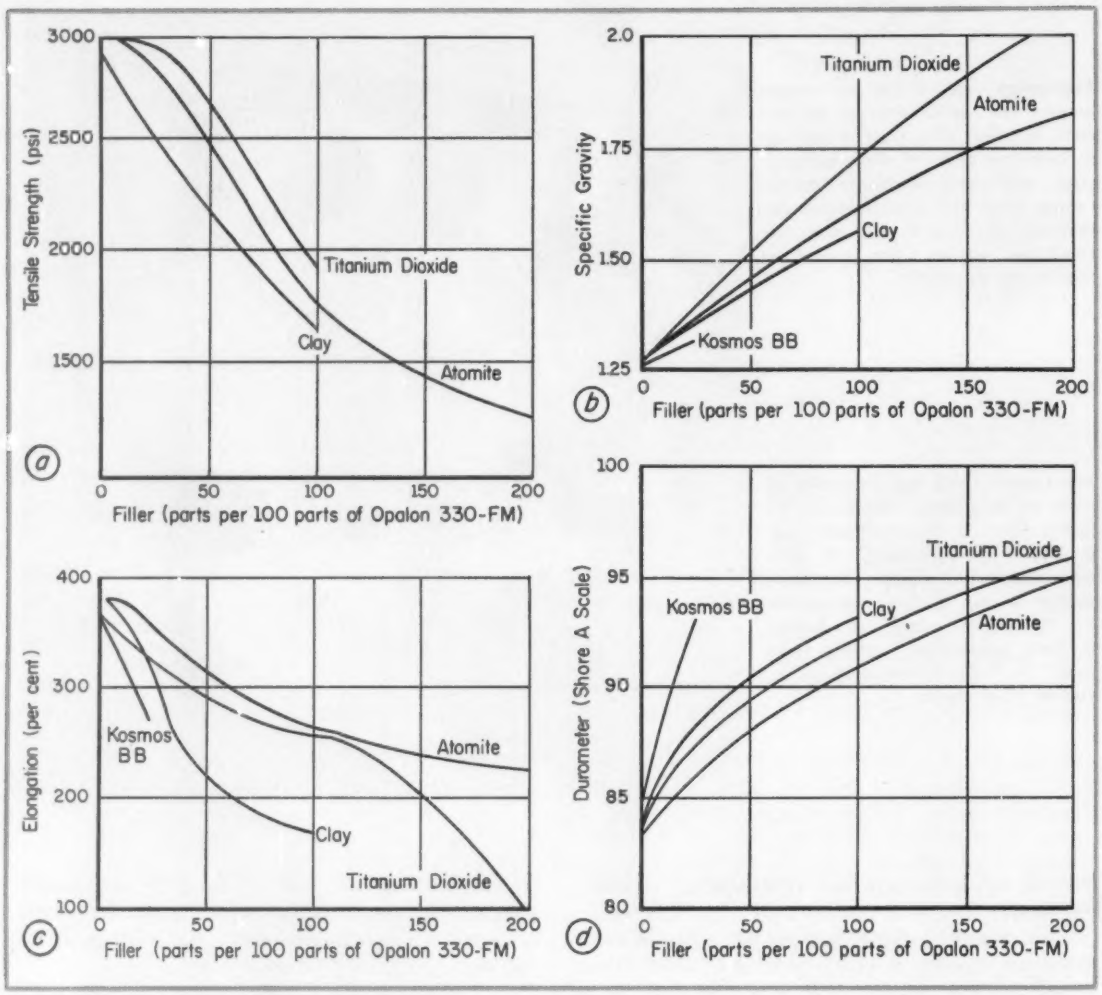
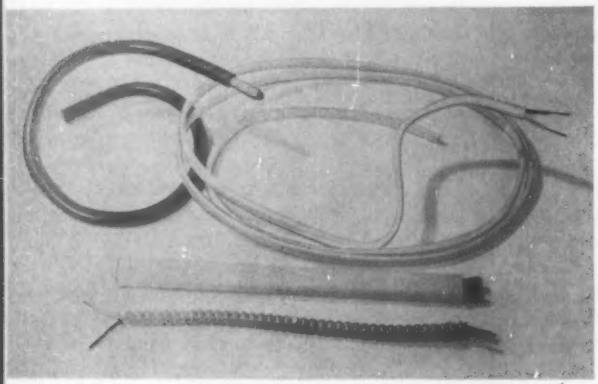


Fig. 3—Effects of various fillers on properties of vinyl-chloride compounds. Basic formulation: Opalon 330-FM, 100 parts; plasticizer, 50 parts; stabilizer, 3 parts.



Outstanding properties of vinyl are utilized in these UL-approved electrical conductors. Water resistance as well as insulation is important in power cable (size 1/0, 600-v, Type TW), top left, and in underground feeder cable, top right. Toughness of PVC qualifies it for portable mine cable, center. High insulation properties of vinyl make possible small-diameter conduit shown at bottom.

Lubricants are usually included in vinyl chloride formulations to promote flow in extruding or molding processes, and to minimize tendencies to stick to dies or molds. Common types are: Stearic acid, stearates of various metals, mineral oils, synthetic or natural waxes, and low-molecular-weight polyethylene.

Excess use can reduce heat sealability, printability, resistance to cut-through, heat stability, and light stability. Some lubricants are incompatible except in limited quantities, and excess will exude to the surface of the plastic.

Next Article in this series covers physical properties of vinyl chloride materials and discusses the effects of environment on design.

Hydraulic Filters

How to ▸ *Predict system contamination* ▸ *Choose best filtering medium*

Hydraulic-system components produce a variety of contaminants. Also, retention ability of a filter varies with its physical configuration and composition of the filtering media. This article provides basic information for predicting contaminants to be expected in a combination of components, and details characteristics of the filter that must be provided to effectively remove the contaminants.

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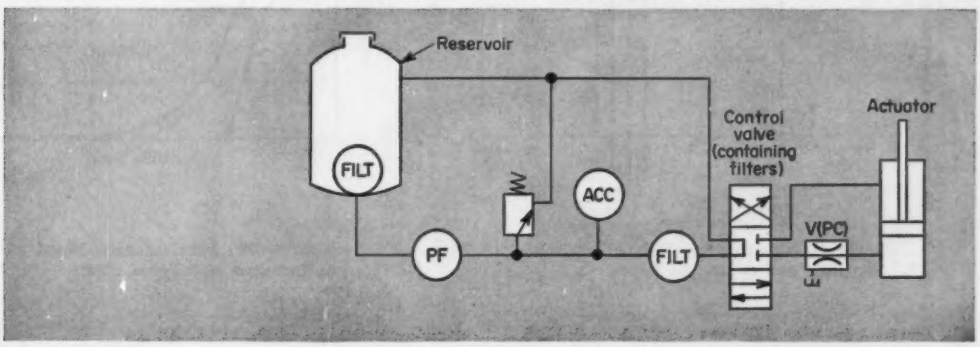
EVERY hydraulic system is a continuous generator of its own contamination. Therefore, filtration is most important. The degree of filtration required depends on the construction of the elements in the system, the care with which they are assembled, and length of operation required between service periods.

A typical hydraulic circuit is shown in Fig. 1.

Fig. 1—Basic components of a hydraulic system. Actual systems may be more elaborate.



The oil, stored in a reservoir, supplies the pump through a reservoir filter. Generally, this filter is intended only for removal of coarse contamination which might damage the pump. A pressure accumulator is generally placed downstream of the pump to even out pressure pulsations and to provide a source of fluid at high pressure, should the demand momentarily exceed the capacity of the pump. A pressure-relief valve is located between the pump and accumulator to relieve excessive pressure when the demand is less than the pump capacity. The pump, accumulator, and relief valve are referred to as the pressure-supply subsystem.

In high-performance designs, the pressure-supply subsystem is followed by a line-type hydraulic filter. This filter should be capable of removing almost all upstream contamination. The fluid then passes through piping of various lengths to a control valve. This valve may be remote, automatic, or servo controlled. A flow-control valve regulates the flow into the actuator. Fluid from the actuator returns to the reservoir through the check and control valves.

Contamination Sources

Each component in the hydraulic system produces contamination as listed in Table 1.

Oxide scale results from forging, welding, brazing or heat treating operations. Pickling and cleaning cannot completely remove such scale when it is deeply imbedded in crevices or small passages. Scale may also be brought into the system with fluid drawn from contaminated storage systems.

Plastic and elastomers, used as dynamic and static seals, appear in the hydraulic system primarily as the result of abrasion.

Oil additives, such as dyes and viscosity improvers, are used in all high-performance hydraulic fluids. Also included in this grouping are preservative substances which decompose to form insoluble residues.

Metal particles are produced by machining and grinding operations during component fabrication, and from the abrasion of metal parts within the hydraulic system. Vibration and chafing of mechanically joined parts may produce large quantities of metallic particles. Metallic seals are also a source of contamination. Metallic particles also result from cavitation in pumps, piping and valves.

Silica sand is introduced in castings which have not been thoroughly cleaned and in oil which has been pumped from contaminated containers. The abrasive action of sand, in addition to producing excessive wear, causes a secondary production of metal particles.

Lapping compounds, also abrasive, are almost impossible to remove completely from component parts.

Process residues include parting compounds and accelerators used in the manufacture of plastics or elastomeric seals and bladders.

Fibers result from wiping during fabrication and

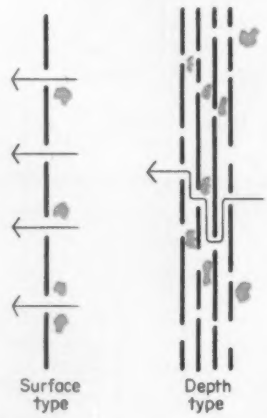


Fig. 2—Comparison of flow paths of surface and depth-type filters.

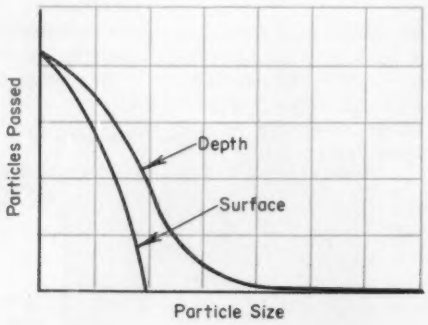


Fig. 3—Particle-retention ability of surface and depth-type filters.

maintenance. They may also result from airborne contamination, bacterial growth or, filters which contain a fibrous media.

Filter Types

Filters may be basically divided into two classes—surface filters and depth filters. The surface filter accomplishes all of its action in a single geometric surface, Fig. 2. Typical examples are strainers used in water, fuel, and hydraulic-supply systems. By comparison, depth-type filters may be considered to remove contamination on a series of parallel surfaces. Filtration occurs throughout the volume of filter material, Fig. 2.

In the surface-type filter, all holes lie in a single surface and are of uniform size. In a depth-type filter, the holes are not of uniform size. For example, imagine a filter to be built of many thin layers. The small holes in the first surface remove a portion of small particles. However, many particles of that same and of larger sizes pass to the second surface, where more of them are removed. This process continues throughout the filter. In addition to this straining in depth, the filtration is supplemented by directional changes in the fluid in the porous structure.

Since all the imaginary planes of a depth filter contain holes larger than the rated size of the filter, there is a statistical probability that large particles can pass through a depth-type filter, as indicated by the arrows in Fig. 2.

In contrast, surface-filter action approaches the absolute. Surface filters have a relatively sharp particle-cutoff point, Fig. 3. Depth filters, however, have a relatively diffused cutoff point, depending on the size, stability and distribution of pores within the filter structure.

Filter media may be exclusively surface or depth type or may combine features of both. For example, strainers and filters of woven filter cloth are almost pure surface-type filters. More complex types, such as wound wire or sintered bronze, combine both surface and depth filtration. Uniform pore size produces surface-filtration characteristics. Depth-filtration characteristics result from the tortuous nature of the pore structure. This latter characteristic causes sedimentation of fine dirt in the pore system.

The cotton pack is classic example of the depth-type filter. It has a good dirt-retaining capacity and good efficiency. Other examples of depth filters include wire wool, paper, sintered bronze, wound string, and porcelain.

Type Comparison

Depth-filter advantages include: 1. The ability to hold a large quantity of contamination. 2. The ability to remove a high percentage of fine material. 3. Low cost. Among the disadvantages are: 1. Large size of the package required. 2. Possibility of channeling. 3. Danger of migration. 4. Possible changes in the characteristics of any organic binders as a result of chemical or thermal action.

The effect of surge flow and vibration is frequently overlooked. Depth filters work best at nominal

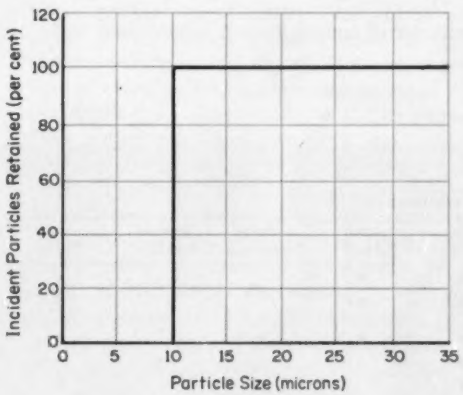


Fig. 4—Ideal performance of 10-micron filter.

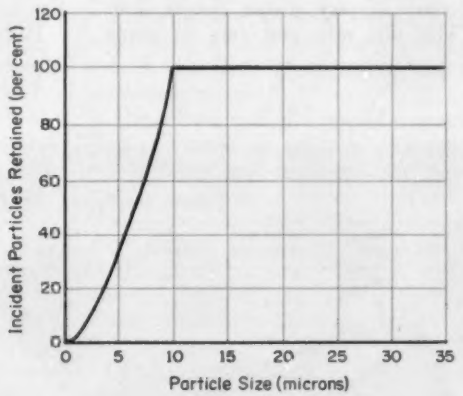


Fig. 5—Actual performance of 10-micron filter.

flow rates and low pressure drop. Under surging conditions, the pressure-drop limits for successful operation are frequently exceeded. Contamination moves slowly from one layer to the next until it passes through the filter.

Surface filter advantages include: 1. Capacity for nearly absolute filtration. 2. Small package size. 3. Ease of cleaning. 4. Ability to resist failure and contaminant migration under conditions of vibration, surging, excessive flow rates, and shock. Disadvantages of surface filters are: 1. Low dirt holding capacity. 2. Generally, higher cost. 3. Contamination migration as a result of filter media "breathing."

Media Characteristics

Depth and surface filters each possess important performance characteristics which relate solely to the media.

These characteristics establish the performance capabilities of each media type.

Specific pressure drop is the pressure drop per unit area of filter surface. The finer the filtration required, the higher the specific pressure drop. However, depth and surface-type filters cover different pressure-drop ranges.

Efficiency is a measure of the ability of a filter to retain particles larger than a given reference dimension. No fluid filter is perfect. The ideal filter would stop passage of all particles larger than the reference size, and pass all particles smaller than that size. Performance of an ideal filter is shown in Fig. 4. The filter retained no particles below 10 microns, and retained all particles greater than 10 microns.

Unfortunately, ideal filter performance such as this does not exist. The dirt on a filter contains a range of particle sizes and shapes, from very fine (less than 1 micron) to very coarse (larger than 100 microns). This dirt may also vary in shape from a spherical form to long, thin fibers. Thus, different types of particles traverse the media with varying difficulty. Long, thin fibers pass easily through surface media but not through depth media. Spherical particles are easily retained by surface filters, but not by depth-type filters.

Even if all the pores in a filter media are identical in size, two or more particles smaller than the hole may approach the hole simultaneously. In this case, the two particles could wedge in the hole in such a manner that there would still be some flow through the hole. This situation occurs primarily with jagged particles in the presence of fibers. The constricted opening which results is capable of removing contamination that is far smaller than the nominal pore size. Thus, a plot of cumulative dirt retained against micron size produces a curve similar to that shown in Fig. 5.

Nothing larger than 10 microns is passed, but a substantial amount of contamination less than that size is retained. The rating for this filter is, therefore, not clearly defined. Certainly, it is a better filter than an ideal 10-micron filter. Hence, it is no longer adequate to call it a 10-micron filter. Under these circumstances, it is convenient to use the concept of filter efficiency as a method of rating filters.

The filter, Fig. 5 removes 100 per cent of the particles greater than 10 microns in size (this is the absolute rating). It removes 80 per cent of the particles greater than 8 microns in size, and 50 per cent of particles greater than 5 microns in size. These percentages are the efficiency ratings for the size indicated. If a filter removes 90 per cent of the 5-micron particles in a contaminant, its nominal rating is stated as 5 microns.

The performance of an actual filter deviates still further from that of an idealized filter. The sizes of the millions of openings in the filter media vary greatly from the nominal dimension. A plot of the percentage of pores of a given size against the nominal pore size produces a curve similar to *A*, Fig. 6.

If the behavior of contamination is combined with

Table 1—Types of Contamination

Component	Oxide Scale	Plastics and Elastomers	Oil Additives	Metal Particles	Airborne Dirt	Silica Sand	Lapping Compound	Process Residues	Fibers
Oil	●		●		●	●			●
Tank	●	●		●	●	●			●
Pressure Relief Valve		●		●	●	●	●		●
Accumulator	●	●		●	●			●	●
Filter	●	●		●	●				●
Piping	●	●		●	●			●	●
Control Valves		●		●	●		●		●
Actuators		●		●	●				●
Pump		●		●	●	●			●

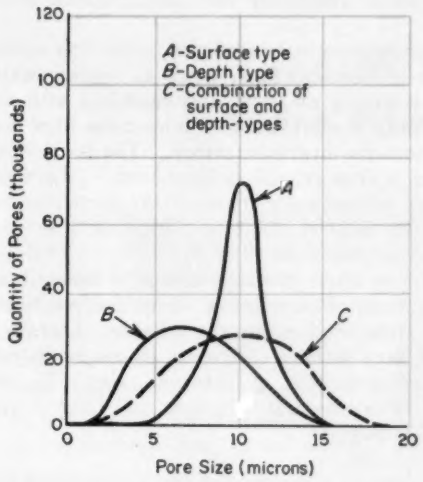


Fig. 6—Typical distribution of pore size of different filter media.

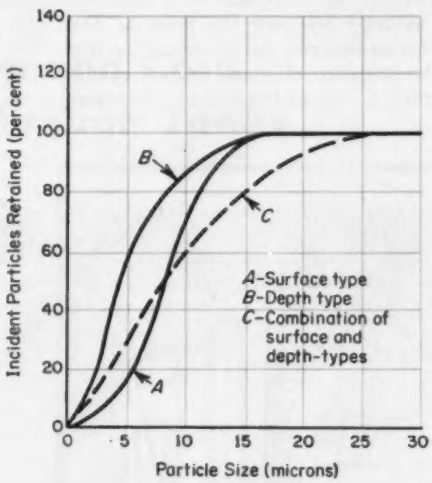


Fig. 7—Typical distribution of particle sizes retained by filters shown in Fig. 6.

the distribution of pore size, the slope of the curve becomes flatter, and the sharp cutoff point disappears, as shown by curve *A*, Fig. 7. The curves shown are for one particular type of contamination. Another type of dirt having a different size distribution will produce a different curve. Therefore, the definition of the absolute rating is statistical and subject to the accuracy of the measurement made.

The filter described by curve *A*, Fig. 6, and curve *A*, Fig. 7, is a surface-type filter with a large number of pores lying in a single plane. A depth-type filter having approximately the same maximum cutoff point, has an effective pore-size distribution as shown by curve *B*, Fig. 6. The pore-size distribution is more uniform. Referring to curve *B*, Fig. 7, the depth-type filter retains a larger percentage of fines (subnominal-size particles) and even a somewhat larger percentage of the relatively coarse particles. However, the curve becomes asymptotic to the 100 per cent line at about the same point.

Frequently, the characteristics demonstrated by filters typical of curves *A* and *B*, Fig. 6, are combined to produce a filter having an effective pore distribution such as that of curve *C*, Fig. 6. The median pore size is almost the same, but the filter captures a greater percentage of fines. Such a filter performance curve is shown by *C*, Fig. 7. The filter efficiencies of the three filters, *A*, *B*, and *C*, Fig. 7, all having the same median pore size, are quite different. Assuming that a 95 per cent efficiency rating is desired, filter *B* has a nominal pore-size rating of 12 microns, filter *A* a rating of 14 microns, and filter *C* a rating of 18 microns. It is possible to obtain a filter of type *C* having a maximum particle rating equivalent to types *A* and *B*. In this case, the median pore size is lower than shown by curve *C*, Fig. 7.

In summary, the performance of a filter must be stated in terms of at least three parameters: 1. The maximum particle size which the filter will pass. 2. A nominal particle size rating. 3. The efficiency of the filter with a specific contaminant at that nominal rating size.

The efficiency assumed by manufacturers for the rated nominal size will vary, usually, between 90 and 98 per cent, depending on the practice of the manufacturer.

The influence of the type of contamination on the filter efficiency has led to a tendency to place more emphasis on the maximum particle rating and to regard the efficiency rating as of secondary importance. Another factor leading to confusion is the effect of fluid velocity on the apparent efficiency of depth media. At low velocities, the finest particles tend to settle out, but high-velocity flow will flush through even large particles.

Dirt-holding capacity of a filter is defined as the amount of contamination, by weight, the filter can hold without increasing the pressure drop beyond a designated level. For most filters, this amount is a few milligrams per square inch.

The dirt holding capacity is not only a function of the weight, but also of the type of contamination.

For example, glass beads may accumulate in considerable quantity on the inlet side of a filter element without seriously affecting the pressure drop because of the spaces between the spheres. Fine contaminants in the presence of gums form a coating on the filter which is almost impervious. Therefore, the quantity of the contaminant which can be held is limited.

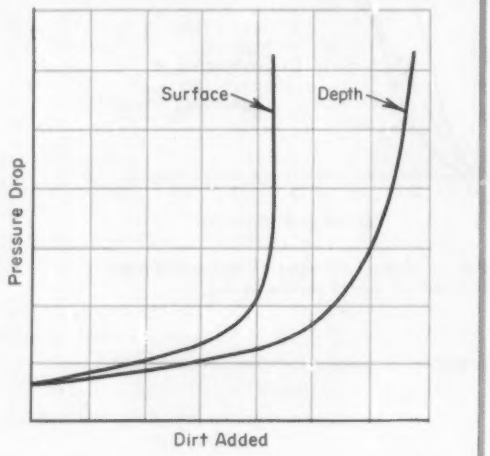


Fig. 8—Results of typical dirt-loading tests.

Dirt-loading tests consist of placing the filter in a circulating system, periodically adding measured quantities of a specified contaminant, and measuring the pressure drop. This procedure is continued until the limiting pressure drop is reached.

Results of a typical dirt-loading test are shown in Fig. 8. The pressure-drop curve at first rises at a rate proportional to the quantity of dirt added. However, as the contamination load increases, the number and size of available slow passages decreases, so that all particles are stopped efficiently. Each increase in load causes an increase in pressure drop. The filter eventually reaches a point at which the addition of any further dirt causes the pressure drop to increase greatly.

The sharp upward turn in the dirt-loading curve, which occurs when the rate of pressure-drop increase becomes disproportionate to the load, is known as the "knee" of the curve. The pressure drop of depth-type filters increases very slowly at first, then more rapidly, and, finally, becomes asymptotic at a high value of dirt loading. The knee of surface filters, on the other hand, is generally quite sharp, and occurs at relatively low contamination level.

Media migration is the tendency of the filter media of "built-in" contamination (such as welding scale, metal particles, or air-borne dust combined with the media during its manufacture) to leave the filter and migrate into the hydraulic system. The problem of migration is thus related to cleanliness. Migration tendencies are generally measured by particle-count methods on samples obtained during or after mechanical vibration of the filter.

Depth-type filters generally consist of loosely held agglomerations of particles or fibers. Surface filters must be rigid and extremely cohesive. Therefore, there are very definite differences in the media-migration characteristics of the two types. In the presence of mechanical vibration, all filter media will tend to migrate.

Cleanability is a measure of how satisfactorily the filter can be removed in the field and cleaned of all accumulated contamination. Unfortunately, no filter is completely cleanable.

Filters contaminated with granular matter can be returned to very nearly their original condition of pressure drop and cleanliness. But filters contaminated with gums of decomposition residues combined with lint and extremely fine matter are very difficult to clean satisfactorily. Such residues, removed from the hydraulic fluid by the filter, penetrate into small crevices of the filter structure. Surface filters are the most easily cleaned. It is difficult to clean satisfactorily a depth-type filter. In many cases, cleaning of depth filters is inadvisable because of the nature of the media involved.

They Say . . .

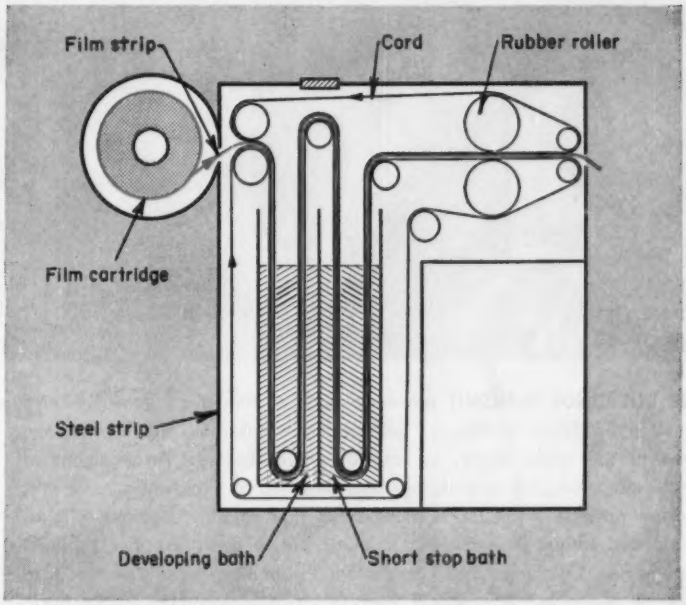
". . . the word *research* as commonly used today, has lost much of its meaning. Just as *stupendous* has come to mean something purported to be a little out of the ordinary, *gigantic*, somewhat larger than usual, and *fantastic*, slightly odd, so 'research' has come, in common parlance, to mean the activities required to come up with a solution to a processing problem, and no later than 8:30 Thursday morning.

"Of course, that isn't research at all. Research has been defined as *careful, systematic, patient study and investigation undertaken to establish facts or principles.* Certainly that is a long way from the demand that something be quickly done to solve an urgent problem so schedules can be met this week.

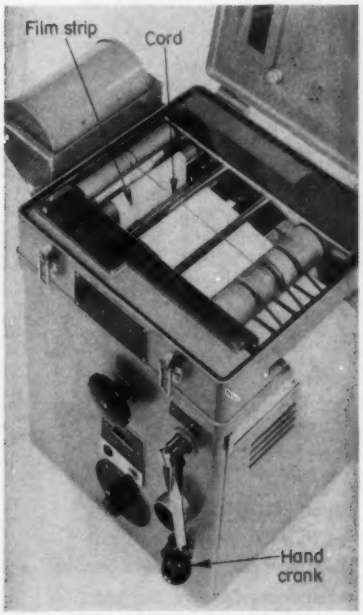
"Not that industry doesn't need this type of trouble shooting. It must have it. The brilliant improvisor is a man of top value and one it would be hard to do without, but he isn't engaged in research, regardless of the title he carries."—E. H. PERKINS, *president, Brooks & Perkins Inc., Detroit, Mich.*

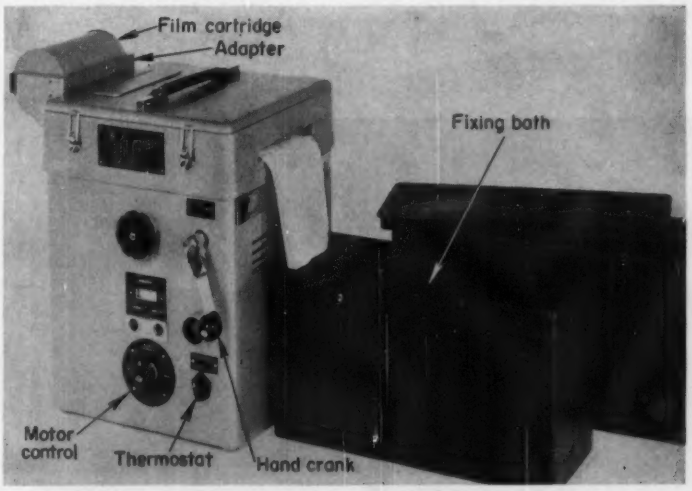
Metal Strip and Cord Steer Film Through Tanks

OSCILLOGRAPH FILM FOLLOWS the labyrinthian course of cord and steel-strip loops through two baths in a daylight developer. Upper cord loop and lower strip loop bend over the same rollers through the part of their paths from the film entrance through the two tanks to the film exit. Film pinched between them moves surely and steadily through the process.



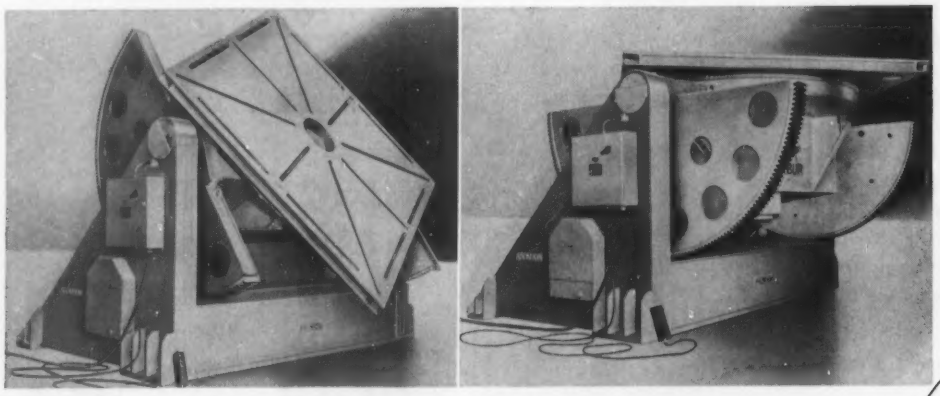
HAND CRANK WINDS film through the process in case of power or motor failure, or if faster developing is required than the motor provides. Thermostat is adjustable from 20 to 30 C. Daylight oscillograph film developer was designed by Siemens & Halske AG, Munich, Germany.



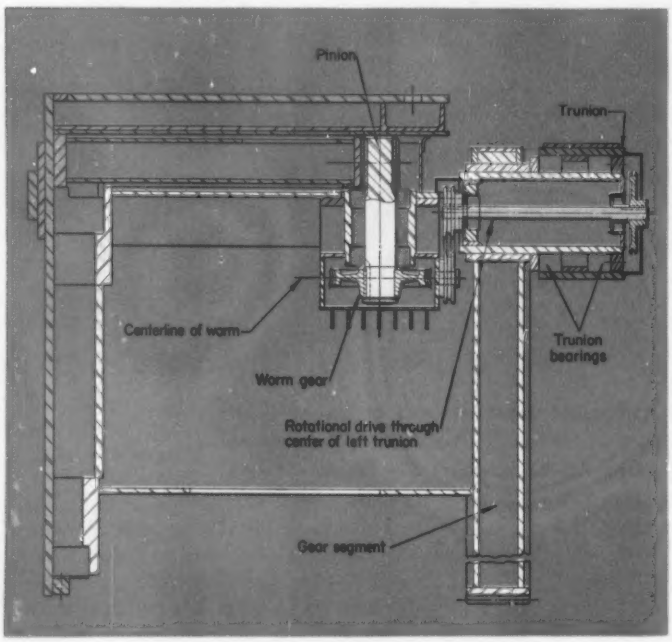


OSCILLOGRAPH CARTRIDGE FITS adapter at inlet. About 2 in. of film are fed into the developer to be seized by the cord-and-strip "jaws." Fixing bath and final rinse are in auxiliary tanks.

Slip Couplings Eliminate Extra Motor;



SLIP COUPLINGS TRANSMIT power to each of two giant gear segments to tilt a 35,000-lb weldment. Self-locking worms hold the load safely, even at the worst angle, in case of power failure. Arrangement of single motor coupled to both legs was designed to avoid the catastrophic racking possible if only one motor of a pair failed. Couplings slip at a planned torque load making it impossible to overstress the U-shaped framework. Couplings also compensate for uneven wear and backlash in gear segments. A separate variable-speed motor, also in the base, rotates the turntable.



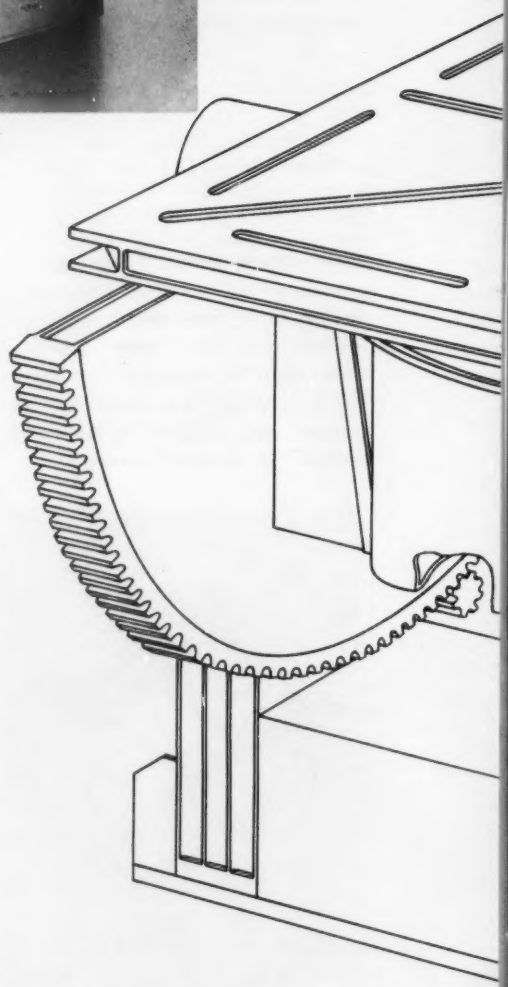
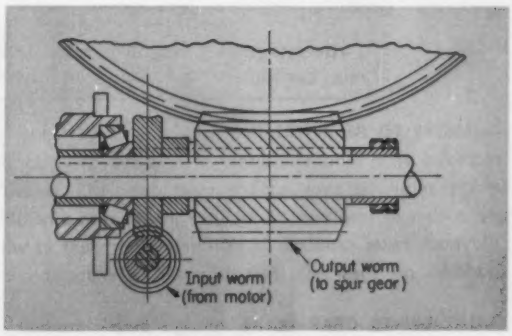
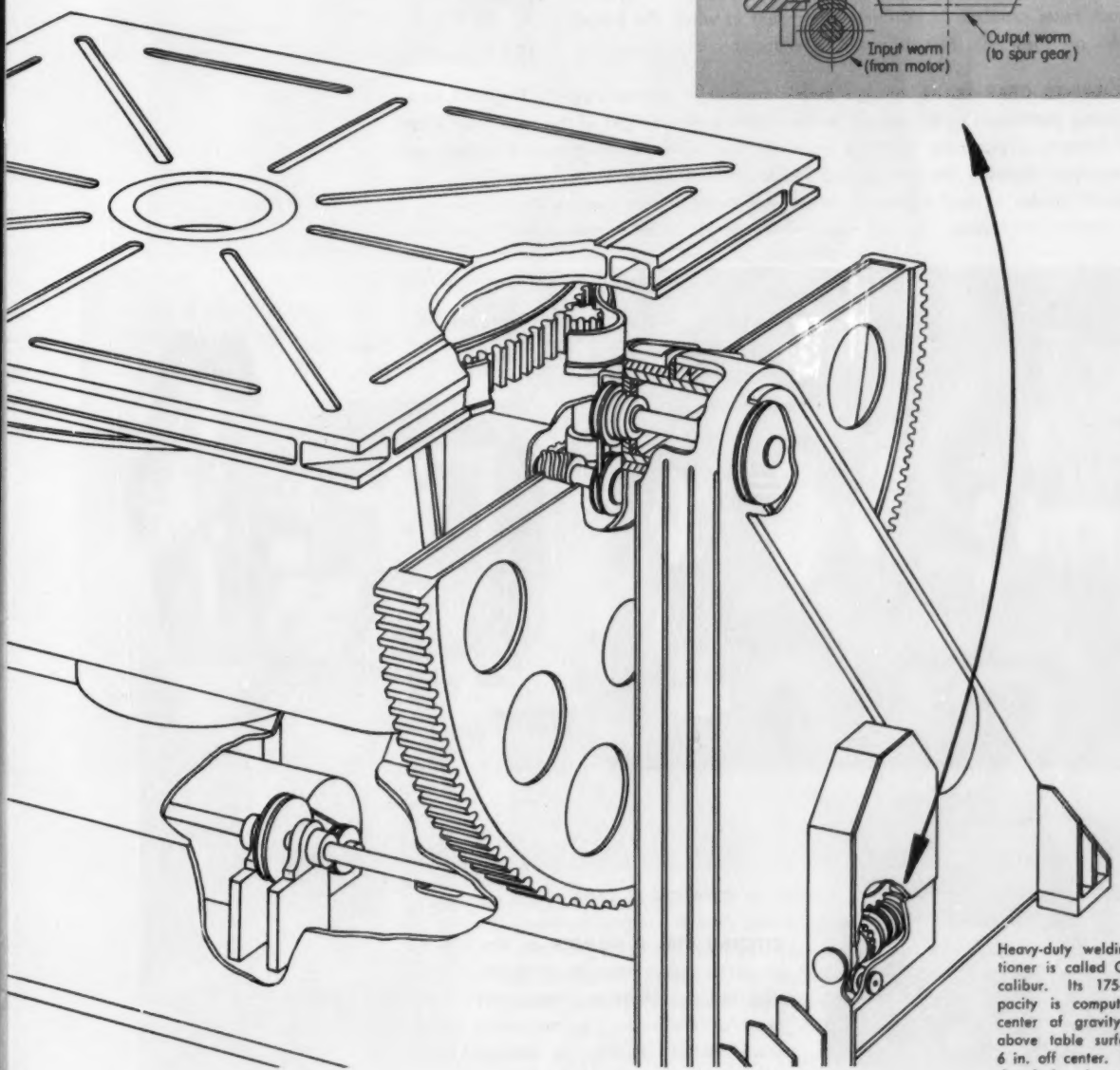


TABLE ROTATION is transmitted through the center of one trunnion. A worm-driven pinion operates the bullgear.

Protect Weld Positioner from Racking Stress

DOUBLE WORM-GEAR REDUCTION reverses the drive, forms the safety locking feature, and furnishes the motor with a mechanical advantage of 396:1 over the spur gear driving the tilting segment.



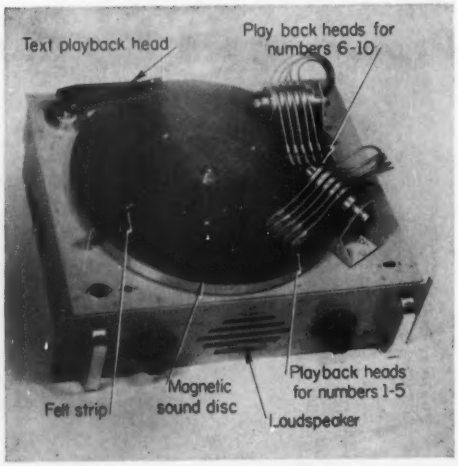


Heavy-duty welding positioner is called G350 Excalibur. Its 175-ton capacity is computed with center of gravity 12 in. above table surface and 6 in. off center. It's produced by Aronson Machine Co., Arcade, N. Y.

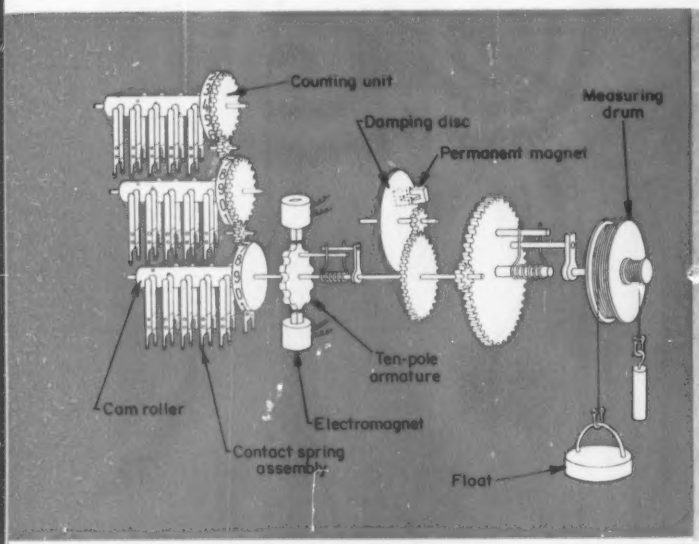
Cam-Tripped Playing Arms Insert Voice-Recorded Numbers in River Report

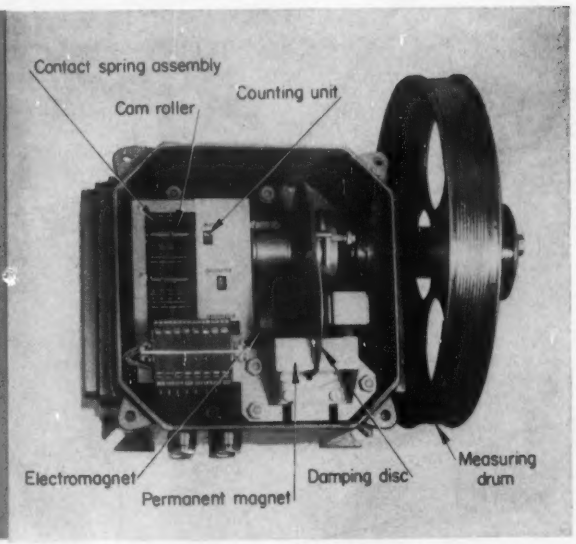
"Riverstage at Cologne is nine meters six decimeters and four centimeters"

NUMBERS TO BE INSERTED in a verbal flood stage report are pre-recorded on a magnetic disc. A magnetic playback head is permanently mounted over each number position. Heads are actuated by a cam in response to changes in the river's height. A separate playback head produces a standard report text in which the proper numbers are inserted. Felt strip acts as a duster.



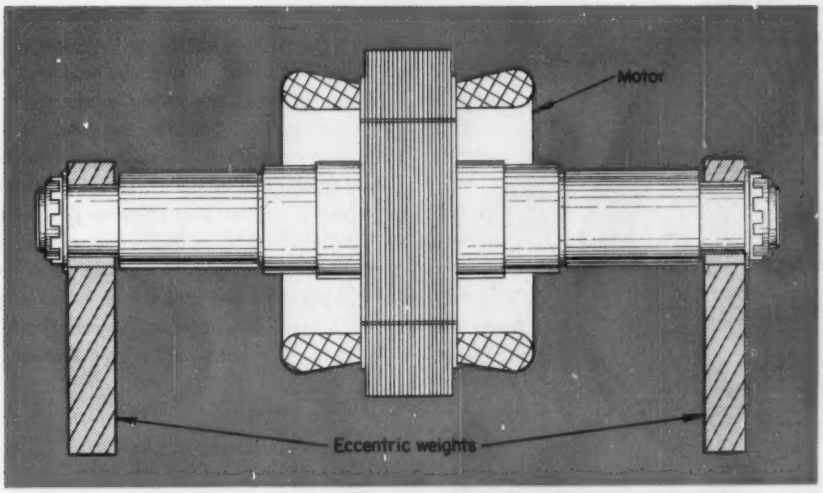
FLOAT DRIVES GEAR TRAIN through pulley drum with counterweight. Playback heads are always positioned to correspond to the instantaneous height of the river. Command signal triggers a playback sequence in which the standard report text is played back with numbers opposite the cam-loaded heads inserted at the proper places in the text. Equipment shown is used in Europe where the metric system permits simple gearing to accommodate ten figures. A refinement of the design could accommodate English units.



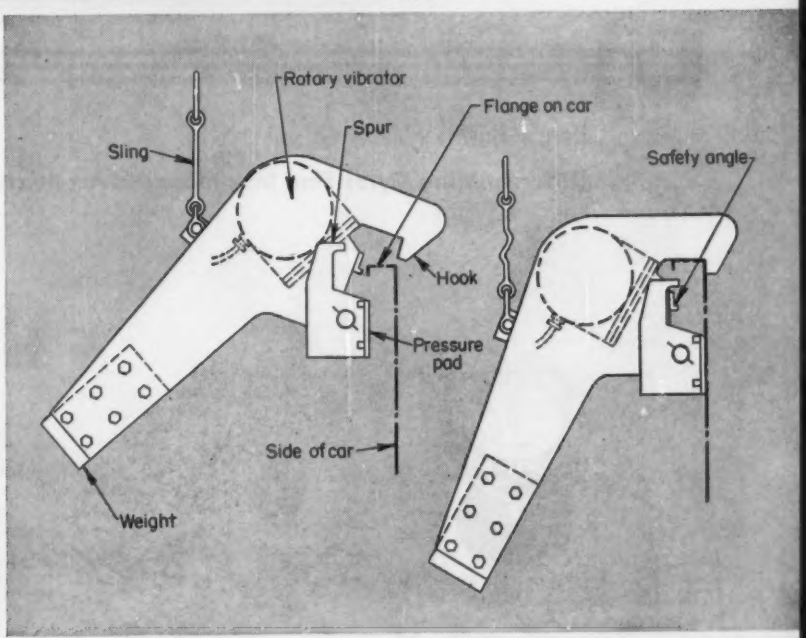


CITIZENS DIAL A NUMBER on the phone to get a report on river conditions. Report includes place of measurement and level of the river. Instantaneous river level verbal reporter is designed by Askania-Werke AG, Berlin, Germany.

Railroad Car Shaker Mounts With Self-Gripping Gravity Lock

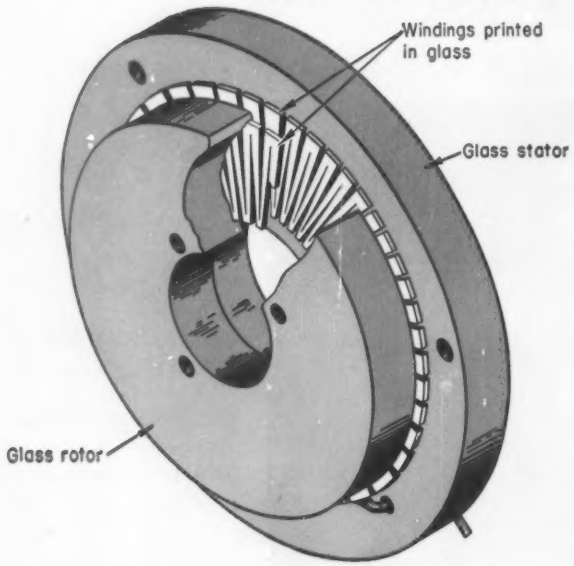


OSCILLATING MOTION of a railroad car shaker comes from a rotary vibrator. Heavy eccentric weights are mounted at each end of a motor shaft. Inertia of spinning weights furnishes a strong enough vibration to shake out the heaviest railroad car.



HOIST RING IS LOCATED to balance the shaker at the proper car-mounting angle. Gravity clamps the edge of the car side between hook and pressure pad. Car flanges are engaged on the lower edge by a spur on the top of the pressure pad bracket. A special safety angle grips the edge of heavy flange cars.

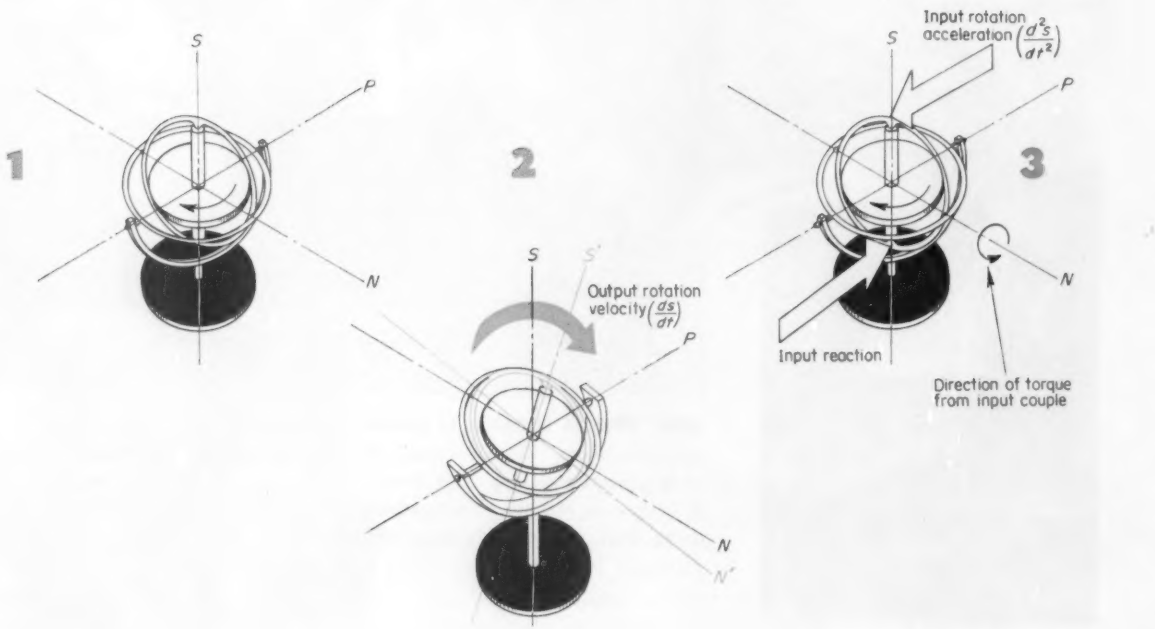
Glass-Etched Electromagnetic Coils



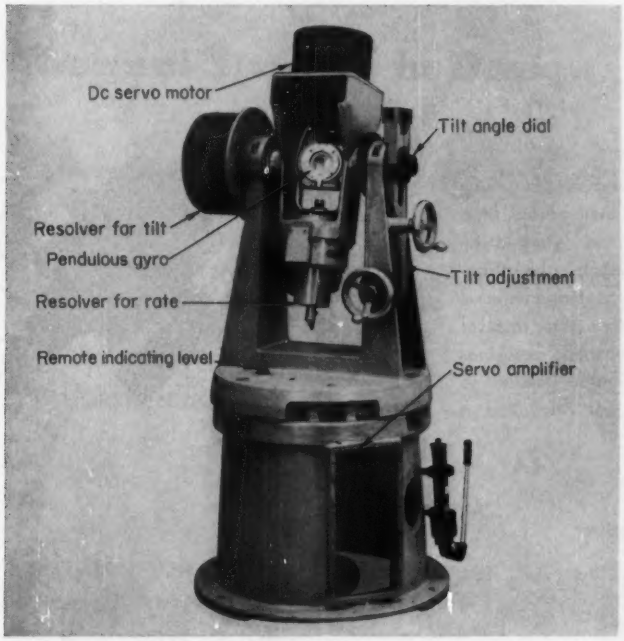
INHERENT PRECISION of a well-balanced gyroscope can be used only if it's accurately calibrated. Gyroscope calibrating stand measures tilt of gyros to 1/4 sec using two glass discs on each of which are etched conducting coils with 360 single-turn poles. One disc, the rotor, rotates with the gyro being calibrated. Its poles move through a magnetic field established by the stator. As each pole of the rotor passes a positive and negative pole of the stator in 2 degrees of rotation, induced current in the rotor coil goes through one complete phase cycle. Related electronic equipment analyzes phase for an angular accuracy of 1/4 sec. Simultaneous induction from all 360 poles averages out small errors in pole spacing.

Here's How . . .

Differentiating Gyros Find Instantaneous Acceleration For Inertial Guidance Systems

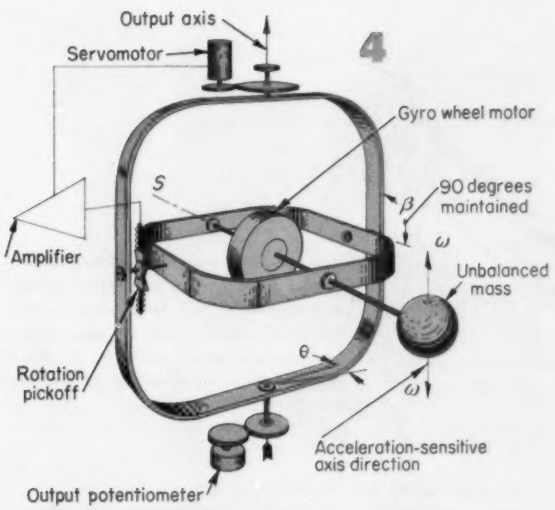


Match Precision of Guidance Gyro



Final Calibration Stand was reported by G. E. Sonntag and J. L. Perample in the first-quarter, 1960, issue of *General Motors Engineering Journal*.

Input acceleration on one axis
Produces proportional output velocity on another



1 Flywheel is free to rotate about three axes, *S*, *N*, and *P* (Spin, nutation, precession).

2 External influence causes a torque about the *N* axis, unbalancing the forces in the system.

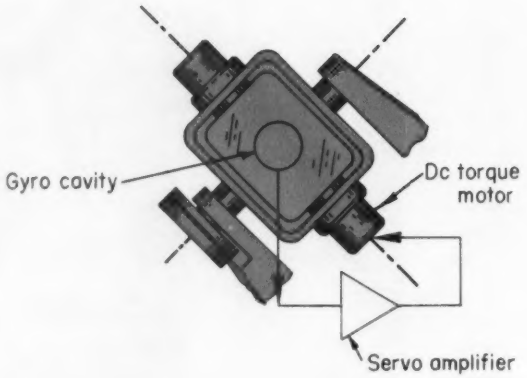
3 New balance of forces is achieved by precession of the gyroscope about the *P* axis. Speed of rotation is proportional to input acceleration and angular position is proportional to input velocity.

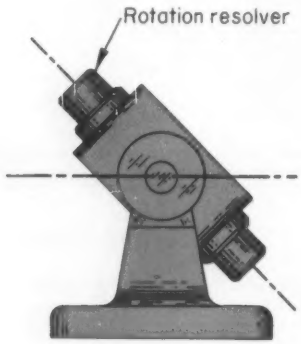
4 Inertial guidance systems use pendulous gyroscopes (mounted on a long arm) to detect linear accelerations. Servo system keeps *S* and *P* axes at right angles. *N* axis rotation pickoff may be a potentiometer. As a result, the gyro is always sensitive to accelerations in the direction of the *P* axis. Readout of compensating rotation on *P* axis furnishes information on original acceleration.

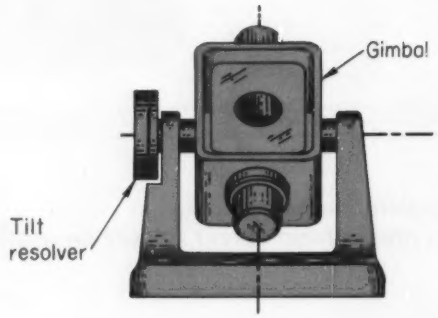
(continued)

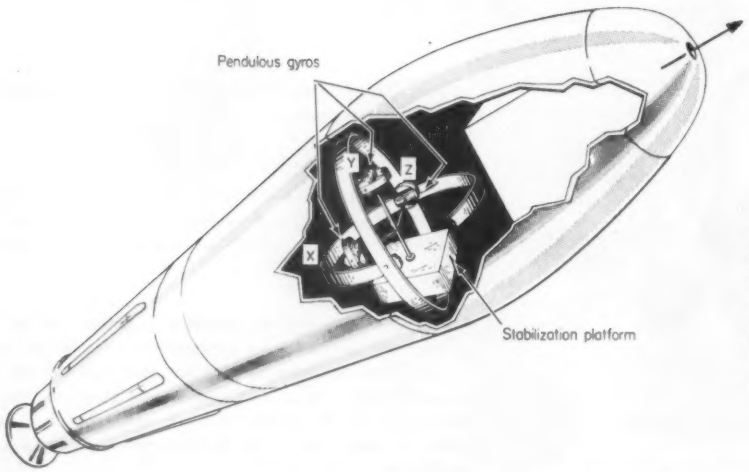
Glass-Etched Electromagnetic Coils Match Precision of Guidance Gyro

GYRO IS TILTED through a measured angle to unbalance the mass attached to the inner gimbal ring. The gyro's outer gimbal ring is mounted rigidly in the test-stand gimbal. Tilt is measured by the glass-etched resolver. Signal from gyro potentiometer is relayed to a dc-torque motor. Another glass resolver similar in design to the one described, measures angular speed from the torque motor needed to stabilize the gyro. Time interval per revolution is accurate to 10^{-5} sec.









Three pendulous gyros, mounted to a space-oriented platform, sense accelerations along three co-ordinate axes for a complete record of a vehicle's speed, direction, location, and accelerations acting on it. Platform orientation is maintained by another gyro system.

Thermal Stresses in Design

Part 20—Thermal Cycling with Steady Stress

- Thermal Ratcheting
- Strain Hardening
- Asymptotic Stresses
- Practical Applications

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Chief, Materials and Structures Research Div.
Lewis Research Center, NASA
Cleveland, Ohio

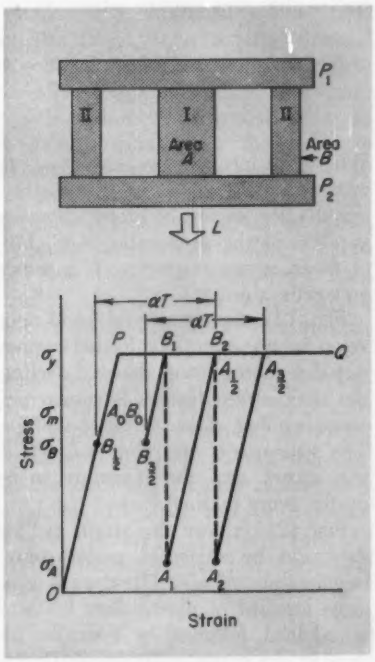


Fig. 122—Model and stress-strain relations in thermal ratcheting.

MANY problems in thermal-stress investigations involve steady loads together with cyclic effects. In some, the load is imposed by external means, for example, by pressure or centrifugal forces. In others, the steady loads result from the partial and irreversible yielding of a portion of the structure during the early stages of the thermal history.

The result of the steady-stress component is, in some cases, to cause unidirectional plastic flow, resulting in progressive growth of the structure. Occasionally, the effect of the steady component of stress is to accelerate fatigue failure similar to the way a steady-stress component reduces the life of a component in conventional fatigue. Previous articles have discussed only those cases in which no steady-stress component was imposed on the cyclic stresses and strains.

Methods of analysis for steady plus alternating stresses are basically no different from those already described. If proper attention is given to the conditions of equilibrium and compatibility, together with the proper stress-strain relations, the correct components of alternating and steady stress and strain will automatically result. However, the phenomenon involved often depends on secondary effects sometimes neglected in simplified analysis. These phenomena are treated separately.

Thermal Ratcheting

The most elementary case in which an externally applied load results in a new phenomenon is illustrated by the two-bar assembly with area ratio $R = A/B$, Fig. 122. For this example, external load L is added to the structure. Initially, the assembly

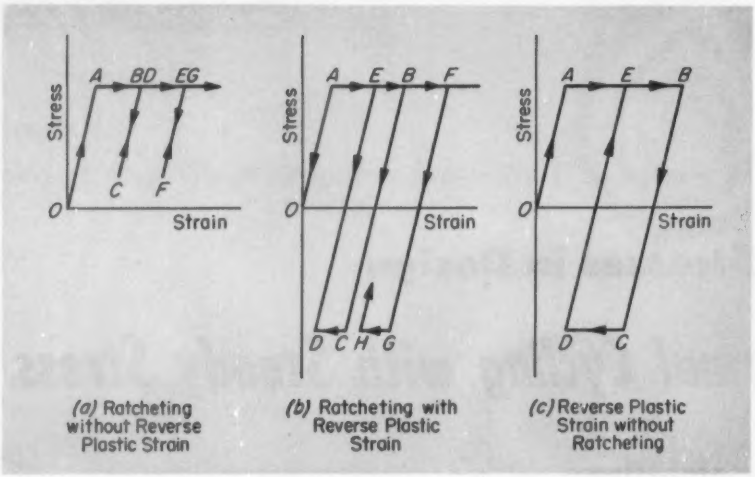


Fig. 123—Several cases that can develop in a system under external load subjected to thermal cycling.

is assumed at uniform temperature and is made of a non-strain hardening material with stress-strain curve OPQ. Load L is uniformly distributed over the entire area $(A + B)$, so that the average stress is $\sigma_m = L/(A + B)$. The stress and strain relation of A and B appear, therefore, at point A_0, B_0 on the elastic portion of the stress-strain curve.

Temperature of outer bar B is assumed to be uniformly increased to temperature T, while bar A is maintained at the reference temperature. The attempted expansion of B transfers some of the load to A. If αT is small, the action may be completely in the elastic range of the material. But, if αT is large enough, the condition indicated by points $A_{1/2}$, $B_{1/2}$ may develop at the end of the first half cycle of heating. Bar A flows plastically, so that its condition is at $A_{1/2}$, while bar B unloads elastically to point $B_{1/2}$. The stress at point $B_{1/2}$ can readily be determined from the condition that the total load carried at the end of the half cycle must still be $L = \sigma_m(A+B)$. Since σ_A becomes the yield stress, σ_y, $B\sigma_B = \sigma_m(A + B) - A\sigma_y$. The strain at $A_{1/2}$ is greater than the strain at $B_{1/2}$ by an amount αT.

When the temperature of B is returned to the reference value, bar A, which has been permanently stretched, unloads along the line $A_{1/2}A_1$ parallel to the elastic line, while bar B assumes a greater portion of the load, straining along the line $B_{1/2}PB_1$. The stress at A_1 again is determined from the total load the two bars must support, so that $A\sigma_A = \sigma_m(A+B) - B\sigma_y$. Strain at B_1 is determined from the fact that, since the two bars are now at the same temperature and their total lengths must be equal, their strains must be the same. Hence, while A was subjected to tensile plastic flow during heating, no corresponding reverse plastic flow occurred during cooling. Conversely, B, which was elastic during heating, was subjected to tensile plastic flow during cooling.

The remaining sequential straining as B is successively heated and cooled is depicted in Fig. 122. For example, after the second heating, A and B are located successively at $A_{3/2}$ and $B_{3/2}$. After the second cooling, the corresponding locations are A_2 and B_2. Hence, each thermal cycle results in a "ratcheting," whereby the over-all length of the total assembly is permanently increased. The increase in length, y, per cycle is determined from

$$y = \alpha T - \frac{\sigma_y - \sigma_B}{E} - \frac{\sigma_y - \sigma_A}{E} \qquad (164)$$

From Equation 164,

$$y = \alpha T - \left(\frac{\sigma_y - \sigma_m}{E}\right)\left(2 + \frac{A}{B} + \frac{B}{A}\right) \qquad (165)$$

Ratcheting thus occurs whenever $y > 0$, or when

$$\sigma_m > \sigma_y - \frac{E\alpha T}{2 + \frac{A}{B} + \frac{B}{A}} \qquad (166)$$

When the mean design stress, σ_m, is approximately equal to the yield stress, ratcheting, or increase in length per cycle, becomes approximately αT, regardless of the area ratio, A/B. For a given value of mean stress, ratcheting is a maximum when the area ratio is unity.

Fig. 123 depicts several conditions that can develop in an externally loaded system which is subjected to nonuniform thermal cycling. In Fig. 123*a*, the stress-strain history is shown only for bar A. A corresponding figure could be prepared for bar B. The sequence of straining is $OABCDEFG$. Ratcheting occurs and the assembly increases in length during every thermal cycle.

Fig. 123*b* shows the strain cycling to which bar A would be subjected under some conditions for large values of αT. Here, each cycle consists of a large amount of plastic flow in the direction of external load, followed by a smaller amount of plastic flow in the opposite direction. The process still consists of a progressive increase in length of the assembly. But, the reverse plastic flow is deleterious

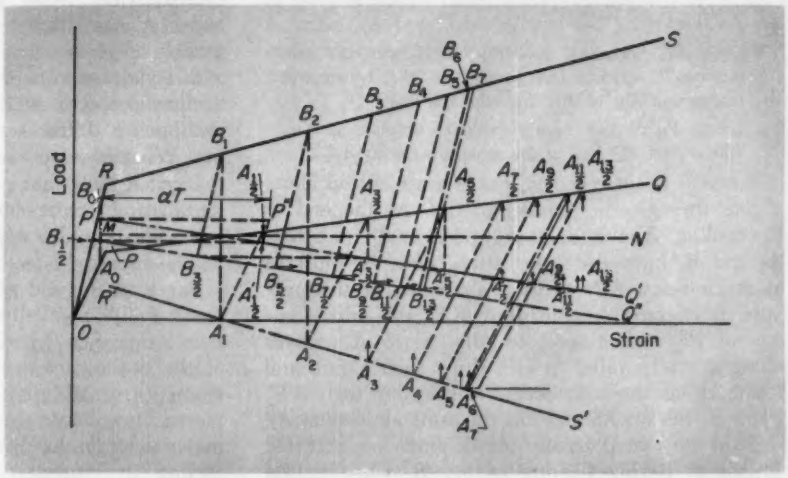


Fig. 124—Load-strain relations for thermal ratcheting of two-bar example.

to the cyclic life of the assembly. The effect on life of combining tensile plastic strain with compressive plastic strain of a smaller magnitude will be discussed in a subsequent article. Of course, the structure may elongate excessively or distort in shape to an unacceptable degree before cracking occurs due to the alternating plastic flow.

Fig. 123c depicts a more usual case. The external load is not high enough to cause ratcheting, the principal effect being cyclic plastic flow of the smaller resisting area, *A*.

Ratcheting is a particularly serious form of thermal deterioration. Occasionally, the progressive distortion destroys design tolerances of the machine part. Even when distortion can be tolerated, however, life can be seriously shortened by the progressive uniaxial straining. When a large thermal expansion is constrained such that the plastic flow is alternately tensile and compressive, the total number of cycles that can be withstood prior to failure is much greater than when the strain is uniaxial. For example, if a material that has 40 per cent ductility in the tensile test is subjected to an arrangement in which an αT strain of 0.004 in. per in. is thermally ratcheted in each cycle, the number of cycles that would be withstood before failure is 100 cycles. On the other hand, if the thermal expansion could be completely constrained, the plastic strain per cycle would be $(\alpha T - 2\varepsilon_y)$ which, for a yield strain ε_y of 0.001 in. per in., would be a cyclic plastic strain of 0.002 in. per in. If Equation 11 is applied,[3] the number of cycles withstood before failure is 10,000. Thus, the difference in cyclic life between thermal ratchet and completely constrained expansion can be a factor of 100. Of course, if the design is arranged to involve no thermal ratchet as well as low constraint of thermal expansion, life can be appreciably increased.

▶ Effect of Strain Hardening

When the material is capable of strain hardening, several different patterns of behavior become possible. Each depends on the average stress due to external load, the area ratio between the portion being temperature cycled and that maintained at constant temperature, and the range of temperature cycling. Again the two-bar mechanism, Fig. 122 is an example, if a stress-strain curve with strain hardening is assumed. Here, the load-strain characteristic of the bars, Fig. 124, rather than stress-strain curves, is used. The conversion is readily made for known areas of the bars. It is assumed that line *OPQ* is the load-strain curve for bar *A*, while *ORS* is the load-strain curve for bar *B*. Bar *B* is alternately heated and cooled, while the temperature of bar *A* remains constant. Only the thermal strains due to the temperature cycling are considered. The effect of temperature on the load-strain curve itself is neglected.

First Cycle: The load is such that initially the bars *A* and *B* are at points A_0 and B_0 on their load-strain curves. The strain in both bars is constant. But, the bars carry different total loads due to differences in their cross sections. The total load carried at all times is $(A_0 + B_0)$. Thus, as the temperature is cycled, the ordinate of the midpoint remains constant and lies along the line *MN*. As *B* is heated and attempts to expand, tensile load is transferred to *A*, causing it to flow plastically. At the end of the first half cycle of heating, *A* must end up at a point $A_{1/2}$ on the line *PQ*, while *B* must unload to $B_{1/2}$ along the line *RO*. To locate $A_{1/2}$ and $B_{1/2}$, two important properties must be maintained: Ordinates of $A_{1/2}$ and $B_{1/2}$ must be equally distant from the horizontal line through *M* to maintain the constant total load and the difference between the abscissas must be the thermal expansion, αT, due to the temperature increase of *B*. These requirements can be achieved by the following graphical construction:

1. Draw a horizontal line *MN* through the midpoint *M*.
2. Draw the line *P'Q'* as the mirror image of *PQ* with respect to *MN*.

[3]References are tabulated at end of article.

3. Draw the horizontal line $P'P''$ of length αT, and through P'' draw a line parallel to OR. Locate the intersection $A'_{1/2}$ of this line with the line $P'Q'$.
4. Locate $B_{1/2}$ on OR having the same ordinate as $A'_{1/2}$, and $A_{1/2}$ on PQ having the same abscissa as $A'_{1/2}$.

When B is again cooled, bar A must unload along a line through $A_{1/2}$ parallel to OP. At the end of the cooling, A must be at A_1 and B at B_1, such that A_1 and B_1 have the same strain. Also, A_1 must be as much below MN as B_1 is above it. For this purpose, it is convenient to draw $R'S'$, the mirror image of RS with respect to MN. Since A unloads along a line parallel to OP, draw such a line and locate A_1 as the intersection of this line with $R'S'$. Point B_1 lies on RS and has the same abscissa of A_1.

Thus far, then, tensile plastic flow has occurred in bar A during heating of bar B, while tensile plastic flow has occurred in bar B during cooling.

Subsequent Cycles: When bar B is again heated, it unloads along a line through B_1 parallel to OR, and such a line can be constructed. To obtain the condition at the end of the second heating cycle, it is convenient to draw a line $B_{1/2}Q''$ through $B_{1/2}$ parallel to $P'Q'$, and to locate the intersection $B_{3/2}$, which obviously differs in abscissa from $A_{3/2}$ by an amount αT, since $B_{1/2}Q''$ is parallel to $P'Q'$ and their horizontal displacement is αT at $B_{1/2}$. Hence, the point $A_{3/2}$ having the same abscissa as $A'_{3/2}$ corresponds to the condition of A at the end of the second heating, while $B_{3/2}$ is the condition of bar B.

Subsequent cooling and heating results in progressive movement of bars A and B as indicated by the construction in the figure. At the end of a heating cycle, A always lies along the line PQ. As seen in the figure, the amount of plastic flow successively diminishes. At the end of the cooling cycles, A lies along the line $R'S'$. The compressive stress in A at the end of cooling progressively increases in magnitude until it surpasses the compressive yield point, after which A becomes subjected to cyclic plastic flow. Since the compressive yield point of a material which has been appreciably strain hardened by tensile prestrain depends on a Bauschinger effect, it is not possible to depict general behavior in Fig. 124 without specifying the Bauschinger effect. For illustrative purposes, the yield load in compression has been taken equal to the initial yield load. The first occurrence of reverse plastic flow appears near the end of the sixth cycle at A_6 when the unloading line $A_{11/2}A'_6$ fails to intersect the line $R'S'$ without first exceeding a compressive load greater than the initial tensile yield load, OP. A small amount of compressive plastic flow is shown as A'_6A_6.

Shakedown: If it is assumed that the yield load in compression remains at the initial yield load, OP, then the reverse plastic flow in compression in the seventh cycle is the strain difference between A'_7 and A_7, and after the seventh cycle the system "shakes down" so that every cycle consists of plastic flow in tension and in compression of amount approximately equal to the strain difference between A'_7 and A_7. Actually, however, it is unreasonable to expect that continued cycling can occur with equal amounts of tensile and compressive plastic flow per cycle while the tensile and compressive yield points differ as much as is shown in the figure. What is more likely is that, after a few cycles, the system will shake down to approximately equal tensile and compressive yield loads. The method for estimating the asymptotic condition for bar A will be discussed later.

Bar B at the end of the heating cycles progresses along $B_{1/2}Q''$ parallel to $P'Q'$, which in turn is the mirror image of PQ with respect to MN. At the end of the cooling cycles, it progresses along the load-strain curve, RS. As with bar A the amount of plastic flow diminishes each cycle. Ultimately the material strain hardens enough so that subsequent cycling is completely elastic, the stresses ranging from a low to a high tensile value for the case illustrated. Continued temperature cycling produces, therefore, alternating elastic stresses having a positive mean value. Design of bar B must, therefore, consider the properties of materials subjected to tensile prestrain followed by alternating stressing between two positive-stress values. This problem will also be discussed later.

Asymptotic Approach

The foregoing discussion described the detailed process whereby progressive straining can take place as a result of thermal cycling. The procedure is at best very complicated. Even when the cycle-by-cycle detail is considered, there is a point in the process where further analysis hinges on unknown material properties. An alternate approach to this problem is to bypass the details of the process, proceeding directly to the shakedown condition, if it exists, by using the concepts of the asymptotic stress range-strain range relation.[18] While such a procedure involves certain approximations and omits certain history effects, its use is merited by the relative ease with which it can be applied, and by its ability to provide definitive answers based on empirical relations drawn from experimental behavior of at least some materials.

Basis: When a detailed analysis of the process is undertaken, the goal is to determine:

1. Whether the plastic straining is unidirectional and progressive with continued cycling, or whether a shakedown condition is achieved whereby the conditions at each point become repetitive with continued thermal cycling, that is, when any tensile plastic flow that occurs in one portion of the cycle is balanced by an equal amount of compressive plastic flow in another portion of the cycle.
2. The over-all deformation of the structure at the time of the shakedown.
3. The cyclic plastic flow at shakedown, or for regions becoming elastic, the mean stress and stress range.

To avoid detailed analysis, the assumption is first made that such shakedown has been achieved, and an analysis is made to determine whether the de-

ductions derived from the assumption are in contradiction with the assumption itself. The principal criterion here is that at least some region within the structure must shake down to completely elastic behavior. Briefly, it is implied that those members of the structure which shake down to a condition of reversed plastic flow cannot support external load. If external load is to be supported, a portion of the structure must shake down to elastic behavior.

Since shakedown is presumed to occur, the relation between stress range and strain range expressed in Equations 157, 158, and 159, or their graphical equivalent, Fig. 119,[19] can be used to determine the stress range and strain range at each point under asymptotic repetitive straining. Solution of the equilibrium and compatibility equations for the problem, together with the stress range-strain range relation leads to explicit determination of the stress and strain ranges asymptotically approached at each point. From these quantities, the individual stresses and strains can be determined.

Simple Example: Line *ORS*, Fig. 125, represents the load-strain curve for the bar *B* based on the virgin stress-strain curve of the material. Point B_n represents the asymptotic condition of *B* achieved after a large number of cycles, *n*, when it is in the unheated condition. Point $B_{n+\frac{1}{2}}$ represents the asymptotic condition of *B* during the portion of the cycle when it is hot.

The relation between the stress range from $B_{n+\frac{1}{2}}$ and B_n and the strain range is given by Equation 158, or by the elastic portion of the stress range vs. strain range curve, Fig. 119.[19]

The condition for bar *A* is not determined from the initial load-strain curve for the material. Bar *A* does not achieve its asymptotic condition until after a sufficient number of cycles have established repetitiveness of the hysteresis loop. According to Equation 157, or Fig. 119, the governing relation between the stress range, σ_A, and the strain range, $\Delta\varepsilon_A$, is more or less independent of the large mean strain that was induced in *A* before the cyclic plastic strain was established. When such repetitiveness has finally been established, the stress in *A* ranges between approximately equal values in tension and compression. The equations of equilibrium at the end of the heating of bar *B*, and upon return to the initial temperature become

$$A\sigma_{A,n+\frac{1}{2}} + B\sigma_{B,n+\frac{1}{2}} = L \tag{167}$$

and

$$A\sigma_{A,n} + B\sigma_{B,n} = L \tag{168}$$

The compatibility equations, stating that the lengths of the bars must at all times be equal, become

$$\varepsilon_{B,n+\frac{1}{2}} + \alpha T = \varepsilon_{A,n+\frac{1}{2}} \tag{169}$$

and

$$\varepsilon_{B,n} = \varepsilon_{A,n} \tag{170}$$

At this point there is no stress-strain relation; there is only a stress range-strain range relation which is valid for both bars *A* and *B*. This relation has been expressed by Equation 157, and for this case becomes

$$\varepsilon_{B,n+\frac{1}{2}} - \varepsilon_{B,n} = \frac{\sigma_{B,n+\frac{1}{2}} - \sigma_{B,n}}{E} \tag{171}$$

and

$$\varepsilon_{A,n+\frac{1}{2}} - \varepsilon_{A,n} = \frac{1}{E}\left(\sigma_{A,n+\frac{1}{2}} - \sigma_{A,n}\right) + M\left(\frac{\sigma_{A,n+\frac{1}{2}} - \sigma_{A,n}}{G}\right)^{\beta/k} \tag{172}$$

where the material constants *M*, *G*, β, and *k* are determined from a few strain cycling tests of the material.[18] Alternatively it can be considered that Equations 171 and 172 are really expressible in one stress range vs. strain range relation.

To solve the system of equations for this problem, subtract Equation 168 from 167, and Equation 170 from 169. Hence,

$$A(\sigma_{A,n+\frac{1}{2}} - \sigma_{A,n}) + B(\sigma_{B,n+\frac{1}{2}} - \sigma_{B,n}) = 0 \tag{173}$$

and

$$(\varepsilon_{A,n+\frac{1}{2}} - \varepsilon_{A,n}) = (\varepsilon_{B,n+\frac{1}{2}} - \varepsilon_{B,n}) + \alpha T \tag{174}$$

Obviously Equations 173 and 174, together with Equations 171 and 172 are sufficient to solve for both the stress ranges and the strain ranges. Load *L* does not enter into the determination of the stress and strain ranges. If an asymptotic repetitive condition is to be established, the stress and strain ranges will be independent of external loading.

Once the stress ranges and strain ranges have been established, it is possible to determine the individual values of stress and strain at the asymptotic condition in each member of the structure. If the stress range at *A* is known, the stresses at the extremes can be determined, since each is half the range. However, only $\sigma_{A,n}$ can be determined from knowledge of the stress range in *A*. The stresses in *B* at the two extremes are then determined from the equilibrium equations once the stresses in *A* are known.

To obtain the strains, it is not sufficient to solve the available system Equations 167 to 172. These equations can establish only strain ranges, but no manipulation can be performed to obtain the individual strains. The key to the determination of strains lies in those components of the structure that do not undergo cyclic plastic flow. Although unidirectional plastic flow may occur in these components, for example in bar *B* of Fig. 125, one of the end points must lie on the stress-strain curve. In this case, the end point is at B_n, and since the stress $\sigma_{B,n}$ is known, strain $\varepsilon_{B,n}$ corresponding to $\sigma_{B,n}$ on the stress-strain curve can be determined. Once this one strain is known, all other strains can be determined from the known strain ranges and the compatibility relations.

Shakedown Criterion: Before proceeding to a gen-

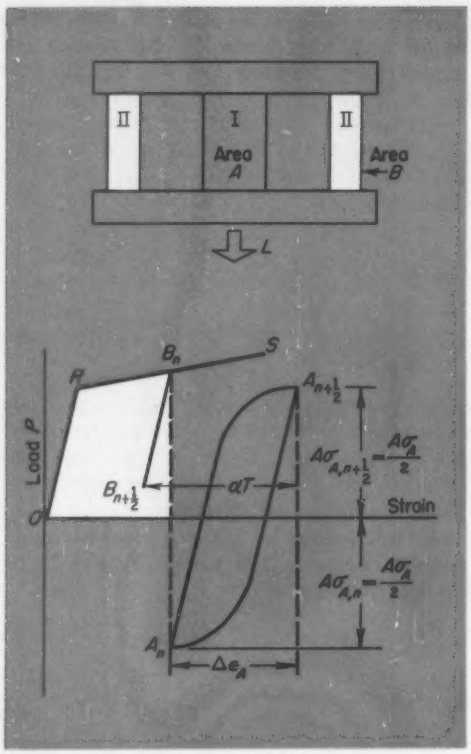


Fig. 125—Load-strain relations asymptotically approached in two-bar assembly supporting external load, while one bar is thermally cycled. Condition for bar *B* determined from initial load-strain curve for material.

eralization of the above method of analysis, it is significant to indicate that the procedure inherently provides a criterion for determining whether a shakedown condition of repetitive cyclic straining can ever occur. If the solution for the stress and strain ranges indicates that every point in the structure is subject to cyclic plastic straining, then shakedown cannot occur, and the solution based on the assumption of shakedown is invalid. No external load can be carried by a structure, every region of which is subjected to cyclic reverse plastic straining.

Generalization: While the foregoing example of the two-bar mechanism under external load represents a very simple case, the solution of this problem leads to a general approach that can be used in much more complex cases. By analogy from the more general cases the following procedure will apply:

1. Form the usual equilibrium and compatibility equations for the problem, replacing at each point the stress by stress range and the strain by strain range.

2. Determine the stress range vs. strain range relation for the material, and plot the relation graphically.[18] This curve replaces the conventional stress-strain relation normally used in plasticity problems.

3. Solve the equilibrium, compatibility, and stress-strain relationships as if the problem were one in deformation-theory plasticity. Neglect all external loads in applying the boundary conditions. Consider only temperature fluctuations as the cause for inducing the stress and strain ranges. The solution of the applicable system of equations provides the stress and strain ranges.

4. Examine the solution of the above equations to determine if shakedown is possible. The criterion is that at least one region of the structure must shake down to an elastic strain range as depicted on the stress range-strain range curve.

5. If shakedown can occur, single out those regions in which cyclic plastic flow is indicated according to the stress range-strain range characteristics of the material. The maximum stresses at these points are half the determined stress ranges.

6. Apply the equilibrium equations, including boundary conditions established by external loading, together with the known stresses in some regions to determine the individual components of stress for the regions that shake down to elastic strain cycling.

7. Apply the known maximum stresses in the regions which become elastic to determine the strains using the basic stress-strain curve for the material.

8. Use the known strains in the regions which shake down to elastic straining, together with the compatibility conditions, to determine the strains in those regions which settle down to cyclic plastic flow.

9. Compute the mean stresses and strains at each point in the structure from the known individual values of stress and strain.

Limitations: The approach described hinges on the validity of the assumption that a stress range vs. strain range characteristic exists for the material independent of the prior history. While this concept has been drawn from the observed behavior of at least several materials, more experimental evidence is needed to generalize this assumption. Furthermore, the experimental evidence is based largely on those cases involving large strain ranges, while the application here is to cases where, at least in some parts of the structure, the strain ranges are small.

Dependence of stress range vs. strain range characteristic on history may be more pronounced for such cases. For example, the procedure is based on the assumption that, regardless of the amount of prior plastic strain, the elastic strain range of the material remains constant. Thus in Fig. 125, it is inherently assumed that the strain range between B_n and $B_{n+\frac{1}{2}}$ will remain elastic if it is less than twice the yield strain at *R*. Such an assumption is sometimes made in other computations involving plasticity theory, but the general validity has not been established.[20] The procedure as described here must, therefore, be regarded as tentative until more experimental evidence of validity has been established.

Finally, it must be recognized that the procedures outlined depend on the asymptotic stress range being achieved, for a given strain range, prior to initiation of fracture. In some cases that have been investigated experimentally, the fracture preceded achievement of the asymptote. Obviously an error

is involved in such cases. Experimental study is required to clarify the more usual expectation, particularly for small strain ranges.

Practical Cases of Thermal Ratcheting

Although the above discussion was, for illustrative purposes, directed specifically at the two-bar assembly under external load and thermal cycling, it is obvious that many practical problems involve the thermal-ratcheting mechanism, and that the type of analysis shown here is applicable to these cases:[21]

1. Pressure vessels subjected to temperature transients in the contained fluid, heated from their exteriors or heated within their walls by nuclear radiations.
2. Pressure vessels clad with material differing from the base metal in coefficient of thermal expansion and subjected to temperature cycling.
3. Pressure vessels made of a metal consisting of crystal phases differing in thermal-expansion coefficients and subjected to temperature cycling.
4. Bimetallic joints in pressure piping subjected to slow cycling of temperature (metals differing in thermal-expansion coefficients).
5. Pressurized piping subjected to high bending or torsional loading.
6. Turbine blades and discs subjected to severe temperature transients and centrifugal loading.
7. High-speed aircraft wings subjected to combined thermal and mechanical loads.
8. Electrical conductors in motors subjected to mechanical and thermal-expansion loads.

Whether the procedure for analyzing a problem with external loads involves the detailed cycle-by-cycle analysis, or whether the details are bypassed in favor of an asymptotic solution, the principal objective of such a computation is to determine the individual stresses and strains in each region of a structure as an aid to estimating permanent growth, distortion, or cyclic life. The first two characteristics can be determined once the strains are known. The cyclic life depends, however, on the derivation of further formulas which include the effect of mean strain for those components subjected to reversed plastic flow, and for the effect of mean stress (or strain) and stress (strain) range for those components which settle down to elastic straining.

The next article in this series will discuss those formulas which include the effect of mean strain in conjunction with reverse plastic flow.

REFERENCES

This article is the twentieth in a series by S. S. Manson on thermal stresses in design. Earlier parts appeared in the following issues of MACHINE DESIGN:

1. June 12, 1958	8. Feb. 19, 1959	15. Nov. 12, 1959
2. June 26, 1958	9. Mar. 5, 1959	16. Nov. 26, 1959
3. Aug. 7, 1958	10. Mar. 19, 1959	17. June 9, 1960
4. Aug. 21, 1958	11. July 9, 1959	18. June 23, 1960
5. Sept. 4, 1958	12. July 23, 1959	19. July 7, 1960
6. Jan. 22, 1959	13. Aug. 6, 1959	
7. Feb. 5, 1959	14. Oct. 29, 1959	

Other references mentioned in this article are:

20. J. N. Goodier and P. G. Hodge—"Elasticity and Plasticity," John Wiley and Sons, New York, 1958, p. 64.
21. D. R. Miller—"Thermal Stress Ratchet Mechanism in Pressure Vessels," Paper 58A-129, ASME, 1958.

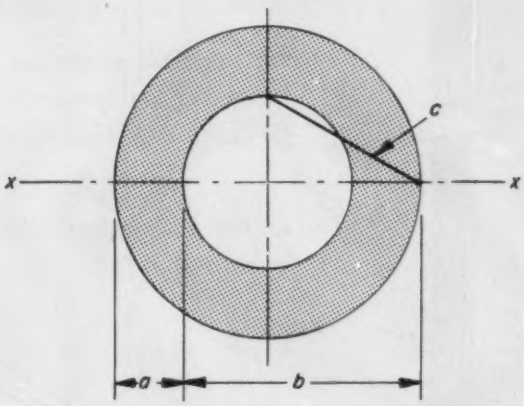
Tips and Techniques

Moment of Inertia of Annular Section

These variations of standard formulas for area and moment of inertia are handy for direct slide-rule use since the highest power used is the square:

$$A = \pi ab$$

$$I_{x\text{-}x} = \frac{\pi}{4} abc^2$$

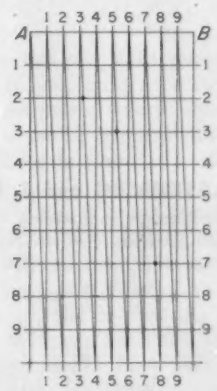


where A is area, $I_{x\text{-}x}$ is moment of inertia, and a, b, and c are dimensions shown on the figure.—R. G. MINARIK, *Carmel, Calif.*

Accurate Dimensions

Highly accurate layout dimensions can be taken from the construction figure shown, where line AB is 1.000 in. long and increments of 0.010 in. can be directly measured.

For example: Vertical lines 11, 22, 33 . . . represent 0.100, 0.200, 0.300 . . . in. respectively; intersection of diagonal line A1 with 11, 22, 33 . . . represent 0.010, 0.020, 0.030 . . . in. respectively,



and the three small dots, reading from top to bottom, are 0.320, 0.530, and 0.770 in.—MAYNARD GRAY, *Dowagiac, Mich.*

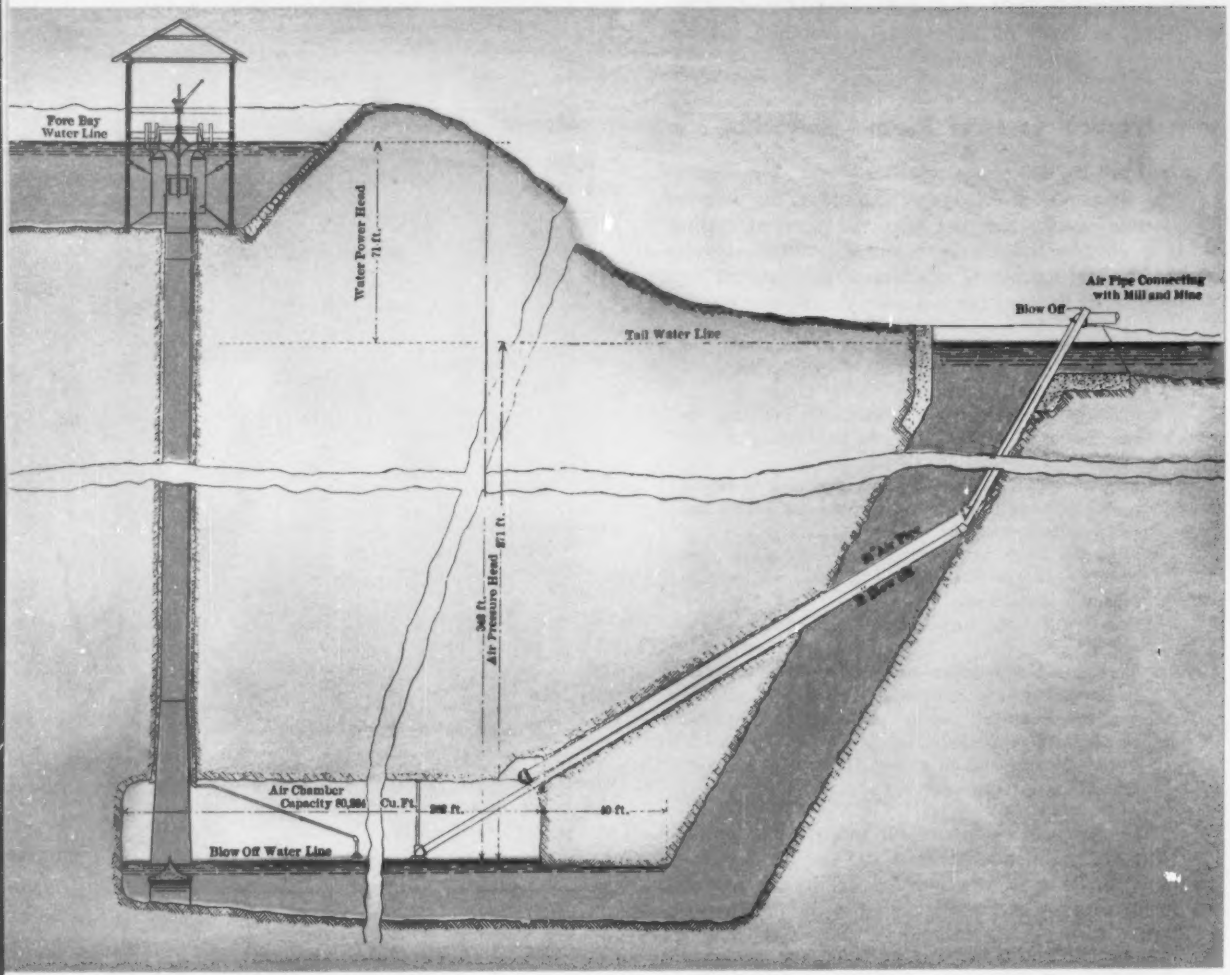


Fig. 1—Vertical section of the Taylor hydraulic air compressor at the Victoria Mine, Ontonagon County, Mich. From Reference 1.

The Fabulous

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Northwestern University
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THE trick of getting compressed air without moving parts in the old compressor shown in Fig. 1 is quite simple. Water mixes with air and, under gravity head, acts as a continuous piston in compressing the air. Efficiency is about 80 per cent.

The "hydraulic air compressor" had as ancester the trompe, an Italian invention first mentioned in 1588. This device, Fig. 2, furnished a continuous air blast to early iron and brass-smelting furnaces. Its action was like that of an aspirator, Fig. 3, with the falling water entrapping a certain amount of air. Water and air separated in the wind box. The water flowed out against a low head making air available at this pressure.

The trompe had wide application in regions of ample water, as in the north of Spain, where it was

Pumps and compressors appear in the mind's eye as machines with moving parts. Pistons, diaphragms, or rotors move in a prescribed manner to supply fluid flow at pressure.

But in generations past, mining engineers used an air compressor that had no moving hardware and yet produced air at 120 psi or so for the compressed-air tools and appurtenances of mines.

Though long since superseded, this compressor was a unique contribution by civil engineers to the evolution of pneumatic power in industry.

Air Compressor

associated with what came to be known as the Catalan furnace. Here, wrought iron was produced directly from iron ore, a process developed in perhaps the 14th century at the time of the Moorish occupation of Spain.

By the turn of the century, the idea of the ancient trompe had been applied to mining operations in colossal proportions and capacity. Fig. 1 depicts one such giant installation designed and completed in 1906 for the Victoria Copper Mining Co. in Ontonagon County, Mich. Available energy was 4000 hp; air was supplied at 117 psi and total capacity was about 35,000 cfm of free air. The Ontonagon River had a fall of 150 ft in 1½ miles. Water was impounded behind the Victoria Dam, 24 ft high and 324 ft between abutments. The river supplied about 45,000 cfm of water to the compressor.

In 1906, this was the most powerful single-unit air compressor in use, built at a cost of about $50 per hp. It was surpassed within three years by the installation of a similar powerplant of 5500 hp on the Montreal River in Ontario, costing about $155 per hp.

General plan of the Victoria plant, Fig. 1, shows that the installation was nothing more than a gigantic trompe, with air being liberated in the underground air chamber. Air pressure was that of the effective water head, the hydrostatic pressure in the outflow shaft. With an effective head of 271 ft, the air pressure was 271(62.4/144) or 117 psi.

The blowoff pipe regulated the pressure within narrow limits. As the air was drawn off, the water level rose in the chamber, sealing its lower end. With decreased air consumption, the air pressure

Fig. 2—An iron works of the 17th century, with the trompe at the left. Note the cam-operated tilt hammer in the foreground. From Reference 2.

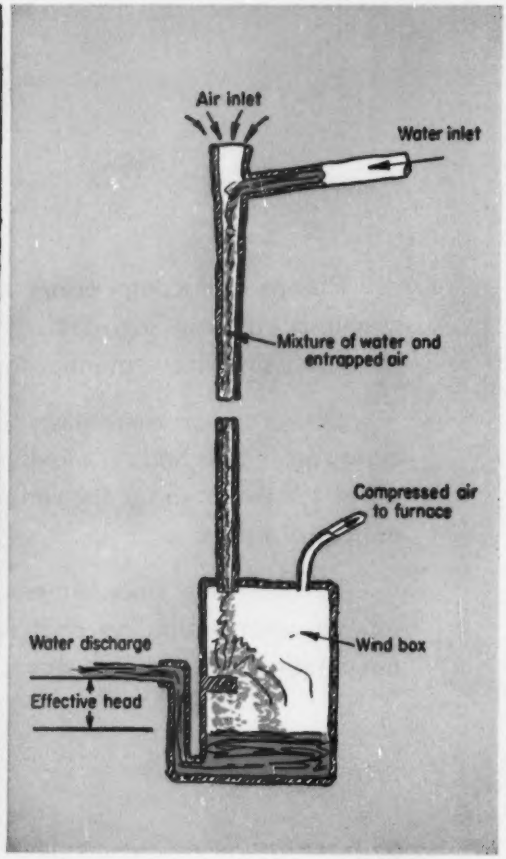

Fig. 3—The trompe in schematic. Its operation is like that of an aspirator.

rose (unless the water was shut off at the intake) and the chamber water level dropped to let the blowoff pipe function. In reference to the Victoria plant, *The Copper Handbook* of 1906 said: ". . . the air rushed upward through three hundred feet of pipe with tremendous force, carrying along with it, in revenge, some of the water which pulled it down, throwing a fine spray hundreds of feet in the air, with a roar that gives the listener some faint idea of the terrific combat of the elements that continues ceaselessly, three hundred feet beneath, where man's cunning has harnessed together those warring elements of air and water, forcing each to coerce the other, and yield their reluctant energy to the pygmy who has entrapped them." In short, the blowoff was a noisy and spectacular operation.

Compression took place isothermally at water temperature. Obviously, the compressed air was saturated with moisture. Oxygen content was reduced to less than 18 per cent from the normal or atmospheric of nearly 21 per cent. This prevented the use of candles, and gave less beneficial ventilation when the tool-air exhaust was used as an assist to a dried-air ventilation system.

Tests run by two faculty members of the Michigan School of Mines showed the plant to have an efficiency of 82 per cent; the builder had guaranteed 70 per cent.

Mine and mill used the air for general power purposes. Equipment included 15-20 Rand drills, 7 pumps raising water from a depth of 2200 ft, a 1500-fpm hoist of 500 hp, and engines for cable lines, saw mills, and the like.

The hydraulic air compressor was a system not suited to small plants, because the installation cost had to be matched against that of a mechanical plant—about $90 per hp. On the other hand, simplicity was the utmost, efficiency was incredibly high, no skilled attendance was required, and the maintenance and running expenses ($2.25 per hp per annum for the Victoria plant) were low.

As a sign of the time—1906—electric power was beginning to move in on older methods. A contemporary article in a mining journal showed that electric power for mine haulage was more economical than mules. The versatility of electricity—especially in the ease of "piping" it—could not be disputed for long.

REFERENCES

1. *Engineering and Mining Journal*, Vol. 83, No. 3, 1907.
2. M. A. Della Fratta et Montalbano—*Practica Minerale*, Bologna, 1678.

Nomogram for finding

FASTENER VIBRATION

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DESIGN of machinery and equipment often requires that a component be secured in such a manner that fastener resonance will not be induced under an anticipated vibration environment. Otherwise, such resonance may permit excessive accelerations of the mounted component and could result in damage to, or malfunction of, the component. Also, resonance may cause premature failure of the fastener itself.

In the design of test fixtures for vibration testing, fasteners which hold the fixture to the exciter must be so designed that their natural frequency is not excited within the frequency range of the proposed test. When such resonant conditions do exist, greater stresses are imposed on the test specimen because of the acceleration magnification. The test environment then becomes uncontrolled.

In most cases, natural frequency of the fasteners must be determined to alleviate or eliminate the problems created by resonance. Usually, fasteners

Nomenclature

A = Cross-sectional area of fastener, sq in.
D = Fastener diameter, in.
E = Young's modulus of elasticity, psi
F_o = Force, lb
f_n = Resonant frequency, cps
g = Acceleration of gravity, in. per sec^2
k = Spring gradient, lb per in.
k_e = Equivalent spring gradient, lb per in.
L = Unsecured length of fastener, in.
M = Secured mass, lb-sec^2 per in.
N = Number of springs or fasteners
t = Time, sec
W = Secured static weight, lb
ω = Circular frequency, rad per sec

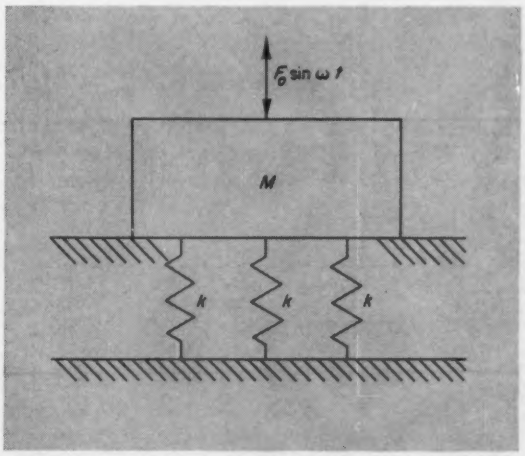


Fig. 1—Mechanical schematic of a mass secured with three similar fasteners.

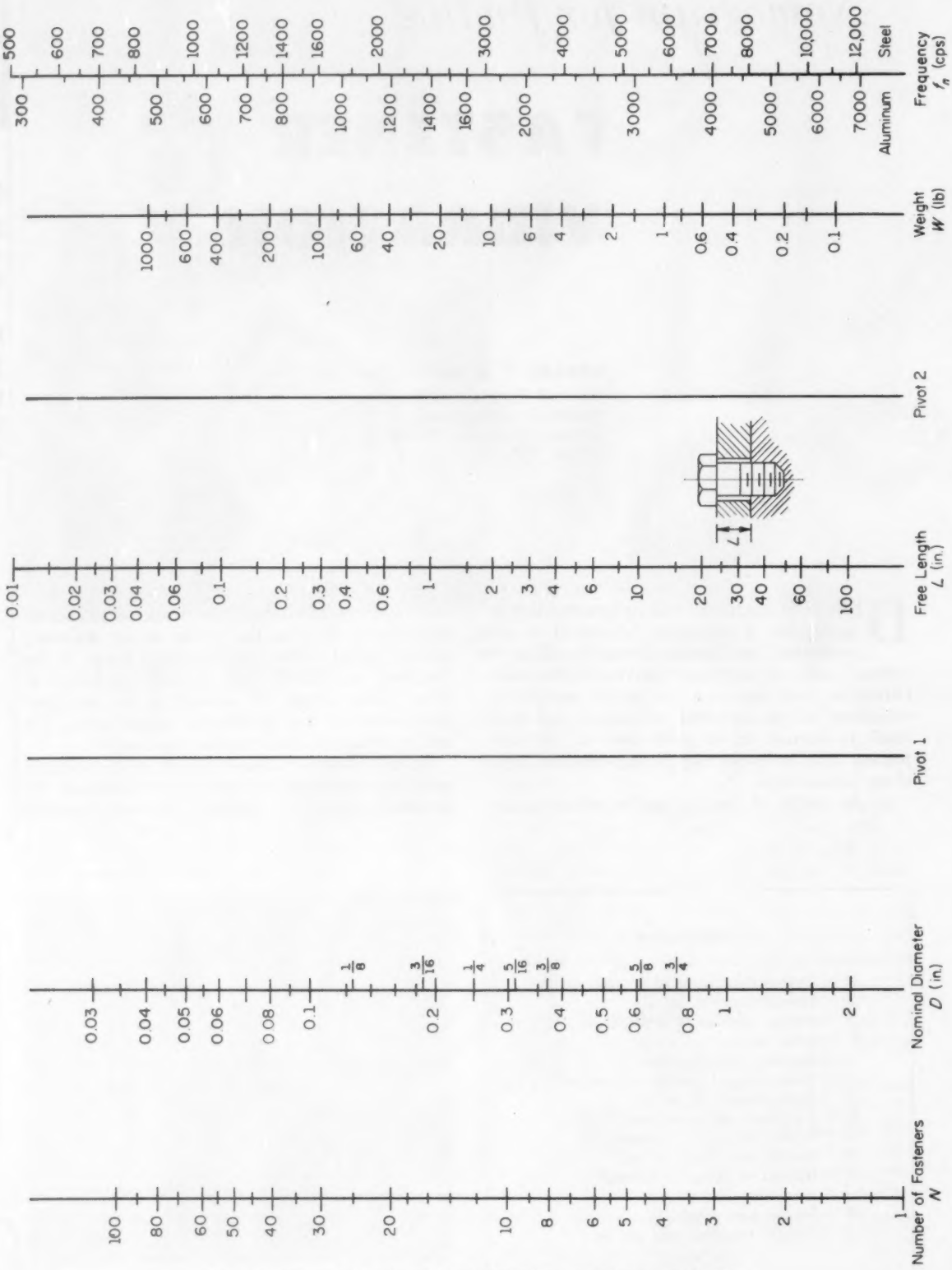


Fig. 2—Nomogram for determining longitudinal vibration of solid cylindrical fasteners. Frequency and nominal-diameter scales may be multiplied or divided by factors of 10 to accommodate other scale values.

are so designed that their resonance occurs well beyond the expected frequency range of vibration in actual service. However, this practice is not always practical because of extreme frequencies or other limitations. In such cases, the fundamental mode of vibration of the attaching members is taken at a much lower frequency than would actually be experienced.

Basically, the fasteners securing a given mass can be considered as individual springs. In Fig. 1 each fastener is assumed to have the same length and diameter and thus the same stiffness. Forced vibration in the direction indicated would excite resonance of the springs at a frequency given by

$$f_n = \frac{1}{2\pi}\left(\frac{k_e g}{W}\right)^{1/2} \quad (1)$$

Furthermore, assuming all the fasteners to be identical,

$$k_e = kN \quad (2)$$

and, applying Hooke's law,

$$k_e = \frac{AEN}{L} \quad (3)$$

Substituting into Equation 1,

$$f_n = \frac{1}{2\pi}\left(\frac{AENg}{LW}\right)^{1/2} \quad (4)$$

or, for circular fasteners,

$$f_n = \frac{D}{4\pi}\left(\frac{EgN\pi}{LW}\right)^{1/2} \quad (5)$$

For steel, substituting a modulus of elasticity of $E = 30 \times 10^6$ into Equation 5 gives

$$f_n = 15{,}200\, D\left(\frac{N}{LW}\right)^{1/2} \quad (6)$$

For aluminum, using $E = 10 \times 10^6$ psi,

$$f_n = 8770\, D\left(\frac{N}{LW}\right)^{1/2} \quad (7)$$

The nomogram, Fig. 2, relates the design parameters of a solid cylinder with axial natural frequency and weight loading. Two examples will illustrate use of the nomogram.

Example 1: Determine the required nominal diameter of mounting bolts used to tie down an electric motor which runs at a speed of 30,000 rpm. Bolt resonance is not to occur during operation. Design limitations dictate a minimum base thickness (bolt length) of 1 in., a bolt material of steel, and a maximum number of four bolts. The motor weighs 100 lb.

SOLUTION: The minimium bolt diameter is found by starting at the far right scale of the nomogram, Fig. 2. Draw a line from a frequency of 500 cps (3000 rpm ÷ 60 sec per min) through 100 on the weight scale. From the intersection of this line with pivot-line 2, draw a line through 1 on the free-length scale. Where this second line crosses pivot 1, draw a third line to 4 on the number-of-fasteners scale. The intersection of this third line with the nominal-diameter scale gives a required diameter of 0.16 in. The closest nominal bolt size greater than this is 3/16 in., which is the desired bolt diameter.

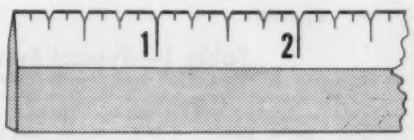
Example 2: Determine the maximum weight capacity of an auxiliary horizontal table connected to the driving head of a vibration exciter by a cylindrical aluminum rod. The driving rod has a 2-in. diameter and a 3-in. length. The auxiliary table, which weighs 10 lb, is to be used in vibration tests with frequencies ranging from 0 to 2000 cps.

SOLUTION: Because resonance of the connecting rod cannot be tolerated within the test frequency range, maximum total driven weight will be determined at 2000 cps. In Fig. 2, draw a line from 1 on number-of-fasteners scale through 2 on nominal-diameter scale. From the intersection of this line with pivot 1, draw a line passing through 3 on the free-length scale. From the intersection of this second line with pivot 2, draw a line to 2000 cps on the frequency scale for aluminum. The intersection of this third line with the weight scale gives the maximum driven weight, which is approximately 25 lb. Since table weight is 10 lb, the maximum load which may be attached is 15 lb.

Tips and Techniques

Line Guide

An ordinary ruler, with its edge V-notched at 1/8 or 1/4 in. intervals, can be used to draw guide lines rapidly. Notching can be done with the edge of a file.



A pencil drawn lightly along the notched edge produces a neat "dimpled" line, handy for tables, bill-of-material sheets, or guide lines for lettering.—L. NAGAICH, *Antlab Inc., Worthington, Ohio.*

Design and fabrication properties of

High-Strength Steels

A. M. HALL

Chief, Alloy Development Div.
Battelle Memorial Institute
Columbus, Ohio

RECENT years have seen the development of several families of steels which can be used at the comparatively high levels of 180,000 to 300,000 psi tensile strength. These materials have found steadily increasing usage. However, applications are critical by nature; the specifications are necessarily stringent; and the utmost in performance is demanded. Therefore, exceptional care must be taken in making and using high-strength steels.

As alloys are compounded for ultimate strength, they lose ductility and toughness; their mechanical properties become increasingly sensitive to small changes in composition and process variables; and they may be more readily deteriorated by their environment.

Low-Alloy Hardenable Steels

A considerable number of low-alloy steels can be hardened to high-strength levels, while retaining fairly good ductility. Prominent are the standard grades: AISI 4130, AISI 4140, AISI 4340, and AMS 6434.

The capability of these steels to be strengthened is a function of their carbon content which usually runs from about 0.28 to 0.55 per cent. Ability to be strengthened throughout the cross section is promoted by the addition of alloying elements. Molybdenum and vanadium help to retain strength at elevated temperatures. Silicon is effective in controlling behavior during tempering.

Typical tensile properties obtainable in these steels are given in Fig. 1. The low-alloy hardenable steels, as a class, are not normally used under conditions where creep and rupture are major considerations. However, some steels in this broad class, known as bolting steels, are specifically designed for those conditions, Table 1.

A number of the low-alloy hardenable steels are produced by vacuum-melting or by the consumable-electrode melting process. Special melting improves certain properties like fatigue resistance and transverse ductility.

Low-alloy hardenable steels in aircraft landing-gear components are regularly made of AISI 4340 with tensile strengths up to 280,000 psi. Other uses include bolts, pins, fittings, and engine mounts. More recent applications are gas-storage bottles for liquid-fueled missiles and cases for solid-fueled rockets. A number of these steels are being considered for rocket cases heat-treated to yield strengths as high as 240,000 psi.

The low-alloy hardenable steels are customarily supplied as annealed or normalized. Sheet up to 120 in. wide by 400 in. long can be produced in thicknesses down to 0.025 in.

The principal reason for using high-strength materials is to hold down or reduce the weight of a

Table 1—Typical Rupture Strength of High-Strength Steels

Temp	Stress (1000 psi) to rupture in time period indicated														
	Low-Alloy Bolting Steel			Hot-Work Die Steel			Martensitic Stainless			Semi-Austenitic Stainless			Cold-Rolled Austenitic		
(F)	10 hr	100 hr	1000 hr	10 hr	100 hr	1000 hr	10 hr	100 hr	1000 hr	10 hr	100 hr	1000 hr	10 hr	100 hr	1000 hr
700	...	...	...	...	...	...	...	...	...	200	195	190	...	...	...
800	...	...	...	...	205	150	...	210	180	190	180	160	150	135	110
900	100	98	96	210	160	120	...	130	90	170	140	100	110	90	65
1000	85	75	60	110	80	60	80	70	60	...	...	...	75	60	45
1100	60	40	20	...	...	...	30	22	15	...	...	...	...	...	...
1200	...	...	...	...	...	...	...	...	...	...	...	...	45	35	25

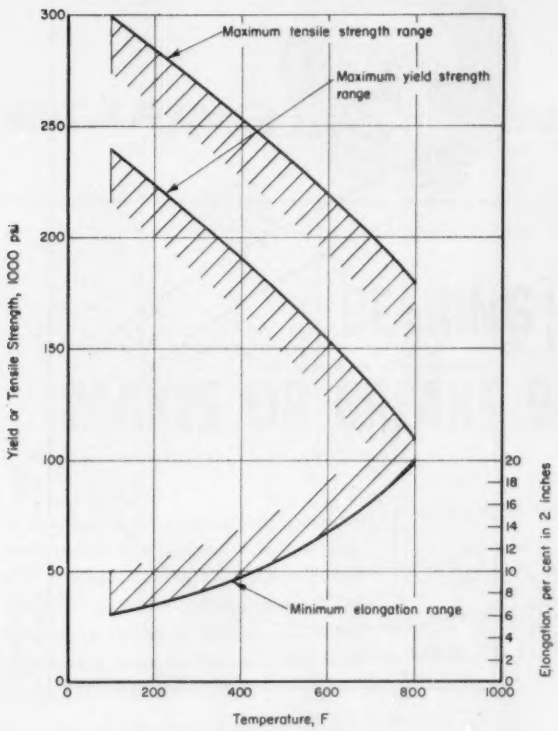


Fig. 1—Typical short-time elevated-temperature tensile properties of low-alloy steels.

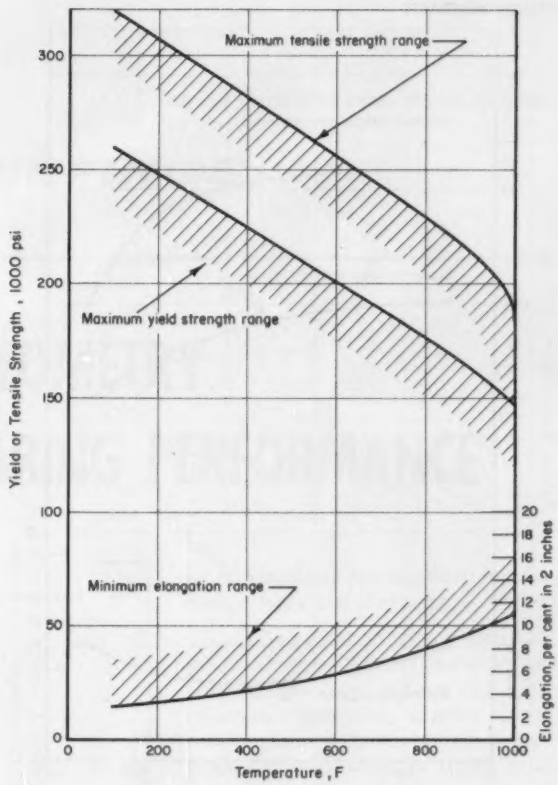


Fig. 2—Typical short-time elevated-temperature tensile properties of hot-work die steels.

structure. However, if the effort is to be effective, the entire cross section of the components should be at full strength. In the case of hardenable steels, this is impossible when their surfaces have become decarburized. In addition, decarburization tends to reduce resistance to fatigue. Some manufacturers have stiff specifications on maximum allowable depth of decarburization of sheet. Others grind or chemically mill off the decarburized layer. Sandwich-rolled sheet seems to be free of decarburization.

The low-alloy hardenable steels can be shaped by a wide variety of methods including machining, spinning, deep-drawing, hydrospinning, explosion-forming, stretch-forming, forging, and extruding. In most cases, they are shaped in the soft (annealed) condition and hardened afterwards. In spinning or drawing large components from sheet stock, the material is frequently given a special annealing treatment before being shaped. The object is to create the most favorable type of microstructure in the steel for the forming operation.

When the material has been severely cold-worked or when components of substantial size or complexity in shape have been welded together, cracking may occur. Driving force behind the cracking is the high level of internal tensile stress. Stress-relieving temperatures range from about 600 to 1200 F, and time at temperature is usually 1 to 2 hr.

An ever-present problem in manufacturing complex items is distortion which results from welding or heat-treating. Such distortion is generally relieved by a sizing operation in the manufacturing process. Distortion from heat-treatment may also be minimized by reducing the severity of the quench.

The low-alloy hardenable steels are welded by a variety of methods. Favored methods are the inert-gas-shielded process used with consumable electrodes when sections are relatively thick, and a tungsten arc for thin sheet or strip. Where the type of joint permits, the submerged-arc process is used to achieve high production rates. After proper hardening and tempering, joint strengths in the range of 180,000 to 230,000 psi yield and 210,000 to 270,000 psi ultimate with corresponding ductilities of 12 to 6 per cent are obtainable.

Table 2—Creep Strength of High-Strength Steels

Temp (F)	Stress (1000 psi) to produce permanent strain indicated in 1000 hr					
	Martensitic Stainless			Semiaustenitic Stainless		
	0.1%	0.2	0.3	0.1%	0.2	0.3
700	115	130	140	120	140	150
800	80	100	115	95	110	120
900	10	20	30	35	40	45

Table 3—Creep Rate of High-Strength Steels

Temp (F)	Stress (1000 psi) to produce creep rate indicated				
	Hot-Work Die Steels	Cold-Rolled Austenitic Stainless			
	10^{-3} %/hr	10^{-5} %/hr	10^{-4}	10^{-3}	10^{-2}
800	195	50	80	120	160
900	130	..	..	...	...
950	100	..	..	...	...
1000	45	..	..	...	...

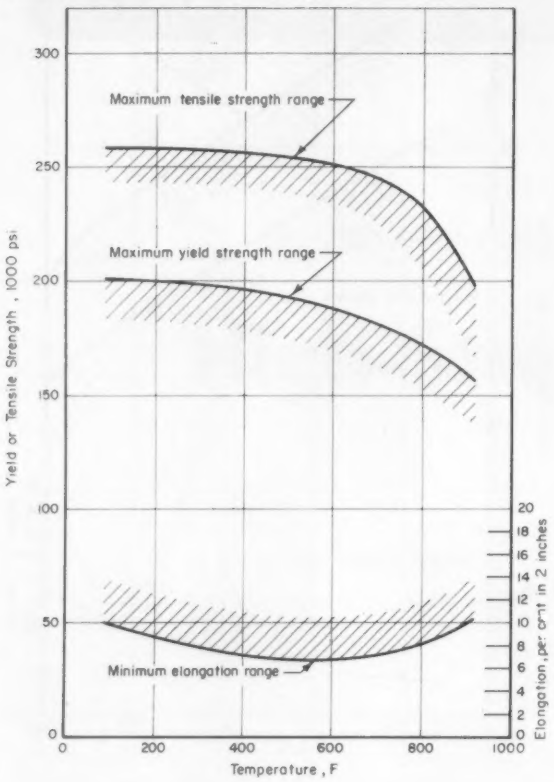


Fig. 3—Typical short-time elevated-temperature tensile properties of martensitic stainless steels.

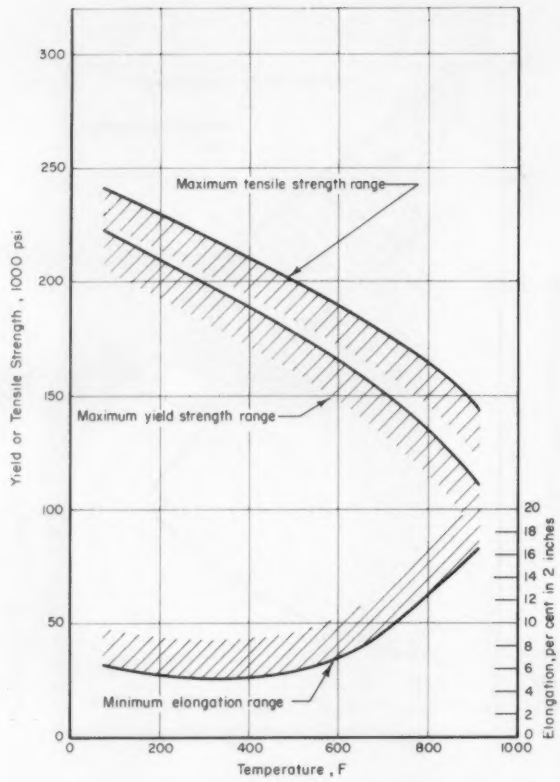


Fig. 4—Typical short-time elevated-temperature tensile properties of semiaustenitic precipitation-hardenable stainless steels.

Chromium Hot-Work Die Steels

Until about 3 years ago the hot-work die steels were used almost exclusively as tools for forming metals at high temperatures. The aircraft and missile manufacturers developed interest in them for structural purposes because of high strength and high resistance to softening at temperatures up to 1000 F. The fact that they are air-hardening is another advantage. Less distortion occurs on air-cooling than on quenching.

There is a large number of chromium hot-work die steels, all proprietary. Carbon ranges from about 0.35 to 0.50 per cent, chromium from 3 to 5 per cent, molybdenum 1 to 5 per cent, and vanadium 0.40 to 1.00 per cent. Some also contain nickel or tungsten. Silicon content is about 1 per cent. The steels fall roughly into two AISI classes: H-11 and H-13. The chief difference between them is vanadium content.

Typical tensile properties of the chromium hot-work die steels are shown in Fig. 2. Rupture and creep properties appear in Tables 1 and 3.

Several fabricators are considering using these steels at yield strengths in the order of 225,000 to 250,000 psi.

As for the low-alloy hardenable steels, the chromium hot-work die steels are susceptible to decarburization. As-received sheet may require surface grinding. Sandwich-rolled sheet is free from decarburization. Although most of the fabrication and heat-treatment of the chromium hot-work die steels in the form of sheet are still largely experimental, fabricators find that these steels can be formed, drawn, and spun with little more difficulty than the more familiar lower-alloyed steels. The trick lies in proper annealing.

The inert-gas tungsten-arc process is the method used chiefly in welding these steels, though covered electrodes have been developed and may be used on thicker sections. Joint efficiencies of 90 to 95 per cent are obtainable.

Martensitic Stainless Steels

Current high-strength martensitic stainless steels have their basis in the AISI 400 series. These steels generally contain 11.5 to 14.0 per cent chromium, and up to 0.30 per cent carbon. They have a long history of use as small forged and machined components for applications requiring high strength and moderate corrosion resistance.

Many modifications of the AISI 410 or 420 alloys are available under a variety of trade names and numbers. Modifications have been directed toward increasing strength, retention of strength at elevated temperatures, and resistance to tearing. Most of the martensitic stainless steels are available in such usual forms as sheet, strip, plate, bar, forgings, and castings. A wide range of mechanical properties is obtainable, Fig. 3 and Tables 1 and 2.

Decarburization may be a problem with the martensitic stainless steels both as supplied from the mill and as heat-treated during fabrica-

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BEARING BRIEFINGS

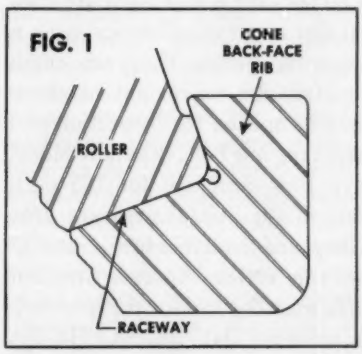
One in a series of technical reports by Bower

BEARING GEOMETRY MAKES OR BREAKS BEARING PERFORMANCE

To develop high capacity and optimum performance in a tapered roller bearing, it is essential that roller alignment be accurate. Correct roller alignment, in turn, depends on a critical geometric relationship between the cone back-face rib, and the cone raceway.

Perfection in this geometric relationship compels the rollers to align themselves perfectly with respect to the bearing geometry, and each roller shares equally in the work that is imposed. Figure 1 diagrams the important elements involved.

When this rib-to-raceway relationship is incorrect (because of either faulty bearing design or manufacturing inaccuracies), rollers experience misalignment and begin to skid and skew under



load. As engineers know, poor performance and premature bearing failure are inevitable under these conditions.

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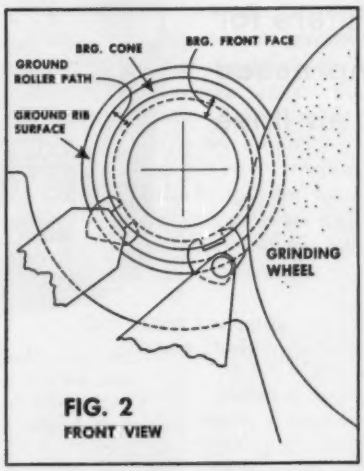
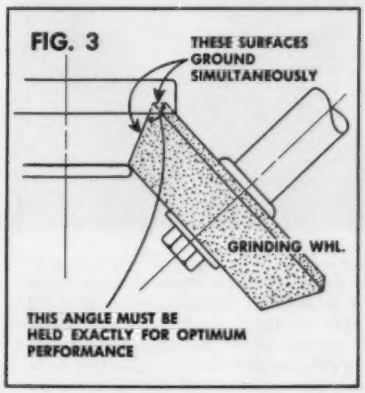


FIG. 2
FRONT VIEW

bearings are designed for maximum life and optimum performance under any operating conditions. It means that Bower bearings retain accurate roller alignment under all speeds and loads up to the maximum for which the bearing is rated.

It's one thing to develop proper bearing design on paper, but quite another to carry it out consistently in manufacture. To this end, Bower engineers were instrumental in the design and development of a unique centerless grinder on which Bower precision grinds each bearing's cone raceway and rib-face simultaneously. The results obtained from these machines invariably meet or surpass Bower's exacting requirements and assure perfect roller alignment.

Figures 2 and 3 are front and top views which illustrate Bower's technique of centerless grinding rib-faces and cone raceways together. As a result, every component in a Bower bearing is perfectly concentric about its rolling axis.



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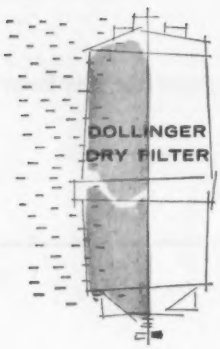

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tion. Controlled atmospheres and protective coatings are resorted to in heat-treating.

The martensitic stainless steels generally have sufficient formability, as annealed, to undergo deep-drawing. However, they tend to be crack-sensitive on welding and some have poor resistance to crack propagation. A common method of welding these steels is the inert-gas tungsten-arc process. Covered electrodes have been developed for use with a number of the steels in this family and may be used in fabricating thick sections. Resistance and flash welding also may be used but, in resistance welding, the nugget must be tempered in place immediately to prevent cracking by hardening on cooling. Preheating for welding is frequently not necessary, but post-heating is essential to avoid cracking. For some of the steels, it is often possible to obtain the desired mechanical properties in the joint merely by tempering after welding.

Semiaustenitic Stainless Steels

These steels may be divided into three broad classes: Martensitic, austenitic, and semiaustenitic.

The martensitic types can be hardened to tensile strengths in the order of 200,000 psi, but have limited ductility.

The austenitic types are quite ductile both as annealed and as aged. They retain a high proportion of their strength up to temperatures in the order of 1250 F.

Major current interest resides in the semiaustenitic class. These alloys are readily formed as annealed and can be hardened to high strength.

The semiaustenitic precipitation-hardenable stainless steels contain 14 to 18 per cent chromium. Each member of the class differs somewhat from the others in composition. However, in every case, the composition is soft and ductile as annealed, but capable of attaining high strength when aged. All alloys of the class are proprietary. Heat-treatments can develop ultimate-tensile strengths of 185,000 to 240,000 psi, with yield strengths of 150,000 to 225,000 psi and corresponding elongations of 12 to 6 per cent, all depending on the specific alloy and heat-treatment. Tensile strengths to 295,000 psi with yield strengths to 290,000 psi and 1 to 3 per cent elongation are obtainable by introducing the cold-working step. Typical mechanical properties are shown in Fig. 4 and Tables 1 and 2.

Fabrication and heat-treating practices vary widely. These steels are readily cold-formed by such methods as deep-drawing, spinning, hydroforming, and stretch-forming. In some cases, components can be hardened merely by ageing directly after cold forming. A problem which arises with these steels is dimensional change accompanying heat-treatment.

Probably the best arc-welding process for the aluminum-containing members of the family is the inert-gas-shielded method. Covered-electrode welding is not recommended because of the difficulty of transferring aluminum across the arc by this process. Optimum mechanical properties are obtained by full heat treatment after welding. The steels can also be spot and seam welded. Decarburization is generally not a problem because of the low carbon content of the steels.

Cold-Rolled Austenitic Stainless Steels

Certain austenitic stainless steels develop very high tensile strengths, on the order of 290,000 psi, when heavily cold-rolled. These steels are classified as the cold-rolled austen-

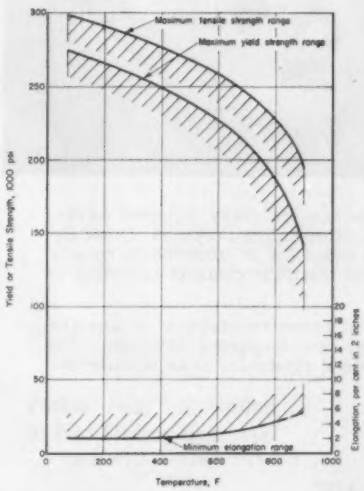

Fig. 5—Typical short-time elevated-temperature properties of cold-rolled austenitic stainless steels.

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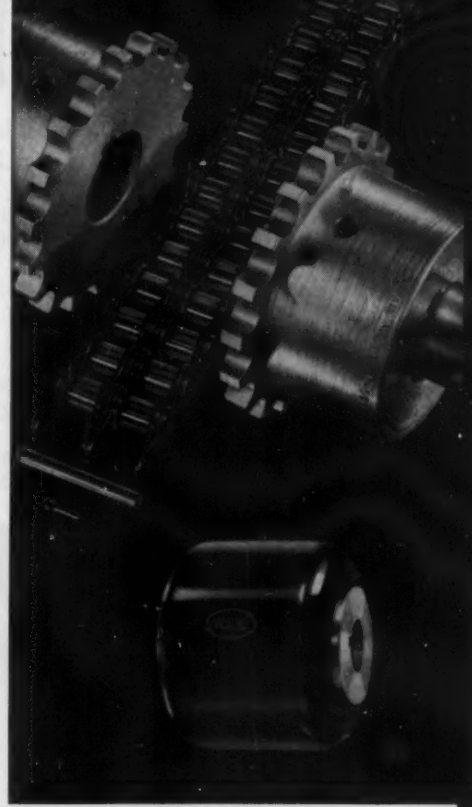

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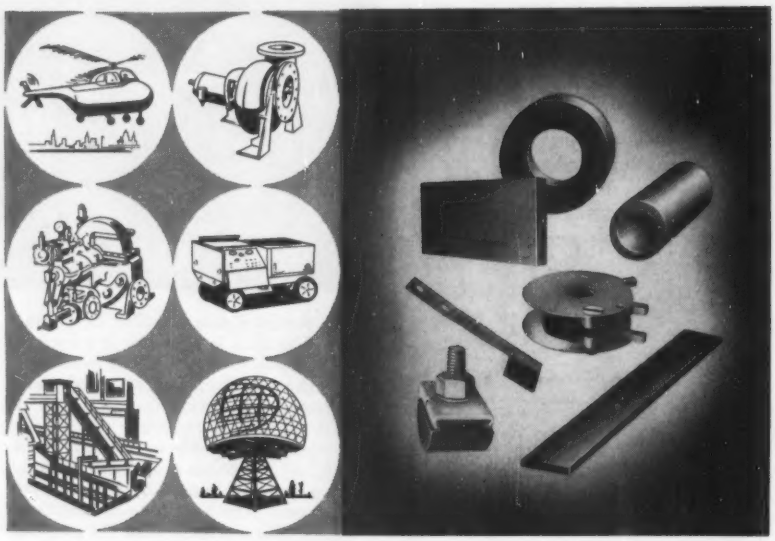

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itic stainless steels. Steels of this type being used or considered by the aircraft industry are the standard AISI 201 and 301 types. Typical tensile properties of the alloys are presented in Fig. 5. Rupture and creep properties are given in Tables 1 and 3.

The cold-rolled stainless steels are generally used in applications in which little or no forming is required but in which high strength and corrosion resistance are needed. They also can be used at moderate temperatures, up to about 800 F for short periods of time.

The cold-rolled stainless steels, of course, do not require any specific heat-treatment other than a stress-relief, which may improve the ductility and strength slightly. In some of these steels, stress relieving tends to reduce slightly the spread in longitudinal and transverse tensile properties caused by the rolling process. Somewhat greater reduction is noted in the spread of the compressive properties.

Because these steels are already heavily cold-worked as supplied, they have limited formability. Therefore, their applications are restricted to those requiring mild forming operations, such as bending to large radii.

These steels, as cold-rolled, can be welded readily by most of the processes suitable for other stainless steels.

ASME Paper No. 60-MD-9, "Some Considerations in the Use of High-Strength Steels," presented at the Design Engineering Conference and Show, New York, May, 1960, 9 pp.

hydraulic

Design of Flapper Valves

P. R. Paslay, Rice Institute

Derivation of a solution, based on an energy method, for determining the static deflection of a particular design of flapper valve which is a thin flat circular disc with radially cantilevered "fingers." The valve is supported at the ends of the fingers and the disc is loaded with a uniform pressure.

This analysis should be satisfactory for design as long as the geo-

metric restrictions given in the analysis are not violated and the frequency of the pressure fluctuations is below the lowest natural frequency of the valve on its supports.

ASME Paper No. 60-SA-3, "Design of Flapper Valves," presented at the Summer Annual Meeting, Dallas, Texas, June, 1960, 5 pp.

techniques

Computers in Design

E. F. Magnusson, mathematician, Control Programming, General Engineering Laboratory, General Electric Co.

Facts about problem types and computer-organization principles. Consider first the distinction between discrete variable and continuous variable. A digital computer operates with the discrete variable; the analog, with the continuous variable. The property of discrete or continuous variable appears in the succession of steps from the physical origin of the problem.

Another important consideration is serial or parallel organization of the computer. Mathematical equations that proceed under step-by-step substitution are readily dealt with by the digital computer. Field problems, mesh problems, and closed-loop feedback control problems display a simultaneous nature, and a parallel-organized computer such as an analog has a distinct advantage.

ASME paper, "Computer in Design," presented at the Design Engineering Conference, New York, May, 1960, 5 pp.

materials

Structural Beryllium

B. B. Muvdi, assistant professor, Dept. of Engineering Mechanics, Michigan College of Mining and Technology

Attempts to produce beryllium having adequate structural characteristics. Specimens of plate beryllium representing five different fabrication methods are compared by metallographic examination, texture analysis, and mechanical tests. From a structural viewpoint, the best combination of uniaxial and biaxial properties is exhibited by commercial grade QMV beryllium powder which is compacted cold and then upset hot. Further advantages of this process over the other four are that it is relatively simple and economical, and yields comparatively good surface finish.

The mechanical tests indicated that, for upset beryllium, plastic deformation before fracture was appreciable in both tension and flexure —even under biaxial stress conditions. Fatigue strength, measured by the cantilever method, is approximately 45 per cent of the tensile strength at 10^7 cycles.

ASTM Preprint No. 79, "Structural Beryllium," presented at the Sixty-third Annual Meeting of the Society, June-July, 1960, 12 pp.

bearings

Stability of Externally-Pressurized Gas Bearings

Lazar Licht, senior research engineer, The Franklin Institute, Laboratories for Research and Development, and Harold Elrod, professor, Department of Mechanical Engineering, Columbia University

Analysis which treats the flow within the gas film in a thrust bearing on a continuous, rather than "lumped" basis. It shows that within the limitations imposed upon the design of the bearing by other considerations, the following parameters or combinations of parameters should be minimized or maximized in order to insure stability:

MINIMIZED: 1. Depth of pockets. 2. Difference between supply and recess pressures. 3. Effective mass of bearing.

MAXIMIZED: 1. Supply nozzle diameter. 2. Length of annulus. 3. Area ratio of annular and pocket regions.

ASME Paper No. 60-APM-5, "A Study of the Stability of Externally Pressurized Gas Bearings," presented at the Summer Conference of the Applied Mechanics Division, University Park, Pa., June, 1960, 9 pp.

lubrication

Partial Film Lubrication In Flat Sliding Bearings

Ronald L. Lenning, Cincinnati Milling Machine Co.

Data of practical nature concerning one phase of partial film lubrication in flat sliding bearings. Various fac-

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For container conveying at high speeds, you need Rex Nylon PlateTop Roller Chains. Nylon top plates are simply "snapped on" to extended pins of a ¾-inch pitch roller chain. The smooth nylon carrying surface protects the conveyed articles...cans, bottles, jars or small packages. Chain can be run unlubricated in applications where lubricant stains on containers are to be avoided. Snap-on top plates are made in several widths. For all the facts, mail the coupon.

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CHAIN Belt Company 412
4643 W. Greenfield Ave.
Milwaukee 1, Wis.
(In Canada: CHAIN Belt (Canada) Ltd., 1181 Sheppard Ave. East, Toronto, Ontario.)

☐ Send my copy of Bulletin No. 5725.
☐ Have a Rex Man call.

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Company.....
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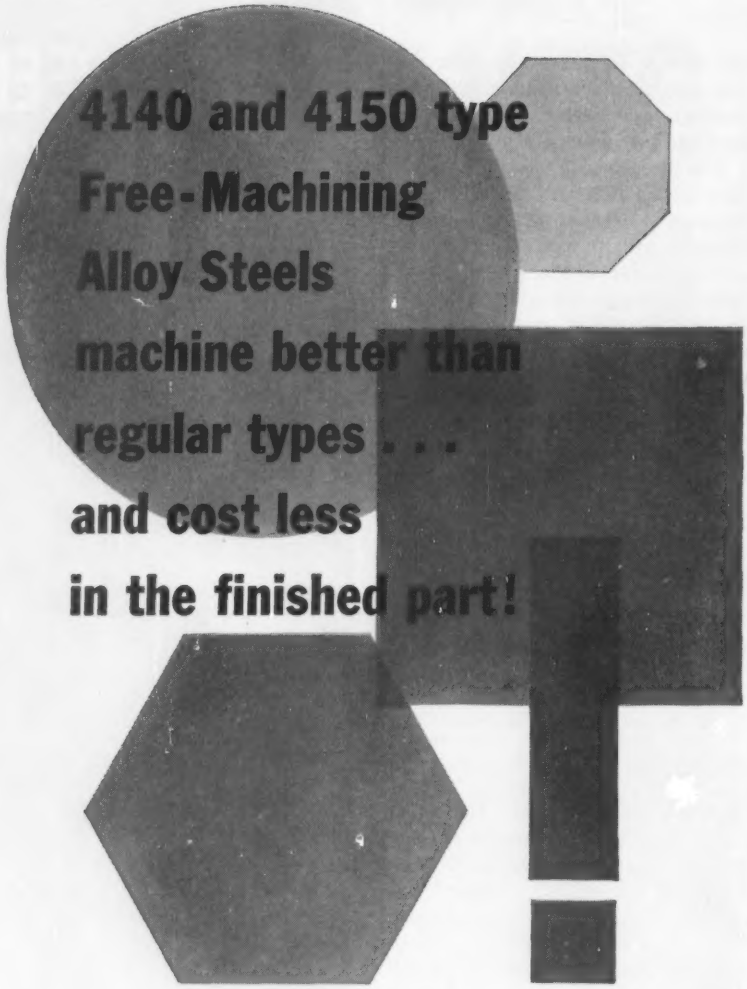
City.....Zone....State.....

Circle 490 on Page 19



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STEEL SERVICE CENTER INSTITUTE

tors influence the surface velocity at which transition from boundary to mixed friction occurs. Friction measurements reveal that the velocity at which transition occurs decreases with: 1. Increasing base oil viscosity. 2. Decreasing surface roughness. 3. Decreasing load.

Except in cases where changes in the surface finish or bulk viscosity may result, the use of an additive does not affect the transition velocity. Moreover, calculations indicate that the percentage of the total load carried by hydrodynamic oil films, under given conditions, is not affected by the use of an additive.

Factors which tend to increase hydrodynamic load-carrying ability also tend to cause transition from boundary to mixed friction to occur at a lower surface velocity.

ASLE Preprint No. 60AM 6B-1, *"The Transition from Boundary to Mixed Friction," presented at the 15th Annual Meeting, Cincinnati, April,* 1960, 14 *pp.*

mechanical

Roller Clutch Design

R. E. Sauzedde, New Departure Div., General Motors Corp.

A review of roller types of one-way clutches, and a general method of design which is consistent with accepted practice by the automotive industry. One-way clutches are used:

1. To change torque converters into fluid couplings;
2. As free wheelers in constant mesh, countershaft type spur gear transmissions;
3. As a means of easing the shift-timing problems in automatic transmissions of the planetary type.

These applications may impose different requirements on a one-way clutch. For example, case 1, a converter application may entail wear consideration, centrifugal effect and almost instantaneous race reversals. The use of an internal cam roller clutch allows the centrifugal force on the rollers, during free wheeling, to practically eliminate wear yet assures positive engagement on fast reversal. In case 2, the problem may be shock loading at synchronization of rotating races.

Circle 491 on Page 19

In case 3, many different conditions may exist, depending on the type of gearing, the type of controls, and the variety of shift sequences.

SAE Paper No. 208B, "Roller Clutch Design," presented at the SAE Summer Meeting, Chicago, June, 1960, 21 pp.

Design of Sprockets and Chain Drives

Edwin A. Paul, chief engineer, Agricultural Chain Div., Chain Belt Co.

Requirements and design of a cast-tooth sprocket intended particularly for agricultural implement service. Requirements include:

1. Smooth, positive engagement must take place between chain and sprocket.
2. Chain must be held in the sprocket with a minimum amount of slack-side tension, with friction between chain and sprocket teeth as low as 5 per cent, with chain tension as high as 1/5 the ultimate strength of the chain, and with a maximum amount of chain elongation due to wear.
3. Allowance must be provided for some build-up of material in the tooth pocket without causing the chain to jump out of the sprockets.

ASAE Paper No. 60-101, "The Design of Sprockets for Chain Drives in Agricultural Machinery," presented at the 1960 Annual Meeting, Ohio State University, June, 1960, 7 pp.

Gear Design for Strength

Evan L. Jones, Axle and Gear Functions Lab., Chrysler Corp.

Basic considerations in the design of gears in power trains, especially in automotive transmissions. "Life-of-the-car" durability is the goal of automotive transmission gear design. To minimize weight and cost, transmission gears are made as small as possible, consistent with the life goal and with size requirements of associated parts.

The same pattern of compact gear sets and high stress is frequently found in planetary automatic transmissions. However, compound planetaries offer a great deal of freedom to the designer. By varying the ways in which the gear sets are compounded, and by selecting input and output members, it is possible for the designer to obtain gear trains of equal size and ratio, but with high tooth loads in one train and low loads in the other.

The principal modes of gear tooth failure in transmissions are: Bending fatigue, compressive fatigue, and scoring. Bending fatigue is the most important.

In the design of helical gear teeth, a conflict of interests occurs between durability requirements and quietness requirements in selecting certain design parameters such as pitch, pressure angle, and helix angle. When a change is made in one of these items to minimize noise, it usually tends to reduce durability. Items that tend to smooth the transfer of load from one tooth to the next tend to influence durability and quietness together.

SAE Paper No. 208C., "Transmission Gear Design for Strength," presented at the SAE Summer Meeting, Chicago, June, 1960, 10 pp.

Simulation of Human Physiological Systems

Ralph W. Stacy and Norman A. Coulter Jr., Division of Biophysics, The Ohio State University

Simulation of components of living systems by nonliving elements, the use of equations to describe the behavior of living systems, the application of feedback-control-system theories and techniques for the study of biological control systems, and the simulation of the mental processes of medical diagnosis by computers.

ASME Paper No. 60-AV-38, "Simulation of Human Physiological Systems," presented at the Aviation Conference, Dallas, Texas, June, 1960, 8 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASAE—American Society of Agricultural Engineers, 420 Main St., St. Joseph, Mo.

ASLE—American Society of Lubrication Engineers, 5 North Wabash Ave., Chicago 2, Ill.; papers 50 cents to members, 75 cents to nonmembers.

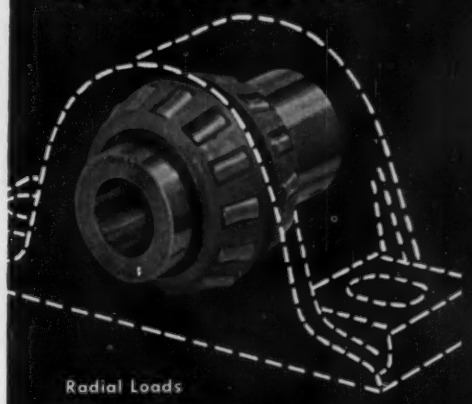
ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 40 cents to members, 80 cents to nonmembers.

ASTM—American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

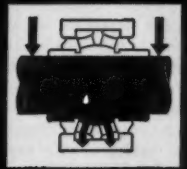
SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

Another PLUS value...

RETAINS CAPACITY UNDER ANY LOAD

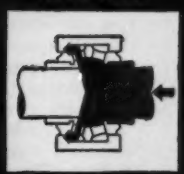


Radial Loads



Load Shown in Black

Thrust Loads



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Shafer Self-Aligning Roller Bearings add plus life to your equipment, even under toughest conditions. Under radial or thrust loading, or ever-changing misalignment totaling 3°, Shafer Bearings retain full load capacity. All loads remain safely centered on the Shafer self-centering rollers—eliminating roller binding and end-wear—eliminating the need for a guide flange, a common source of wear. Mail the coupon.

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( ) Please send Shafer Bearing Catalog 59A.

Name.....
Company.....
Address.....
City.....Zone.....State.....

Circle 492 on Page 19

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Industrial Semiconductors

Brochure titled "Dependable Quality in Quantity" covers complete line of industrial semiconductor products. It lists major specifications such as breakdown voltages, current capacity, and operating temperature range on each product. Five complete lines of semiconductors include germanium industrial power transistors, audio and switching transistors, Mesa transistors, silicon rectifiers, and silicon zener diodes. Motorola Inc., Semiconductor Products Div., 5005 E. McDowell Rd., Phoenix, Ariz.

Circle 601 on Page 19

Packaged Bearings

Hyfilm bearings are described in new bulletin. Line drawing is provided to show how the units operate, including operation of hydrodynamic oil film. Specifications are provided, and data for matching bearings to exact operating requirements are given in tables of life expectancy by loads, speeds, and ambient conditions. 4 pages. Tann Bearing Co., 3750 E. Outer Drive, Detroit 34, Mich.

Circle 602 on Page 19

Spring Materials

"Spring Materials Digest" includes information on three groups of alloys used in the manufacture of springs, and sums up advantages inherent in each alloy. Tables and graphs are included to present much technical information. 8 pages. H. K. Porter Co. Inc., Riverside-Alloy Metal Div., Riverside, N. J.

Circle 603 on Page 19

Clutches and Brakes

Revised folder CFPF4 on electromechanical components and assemblies includes data on six clutches and brakes. Information is given on applications, types, and operation of the various units. 4 pages. Carmody Corp., 2360 Wehrle Dr., Buffalo 21, N. Y.

Circle 604 on Page 19

Mylar Capacitors

Two-color brochure, Data-Log C-102A, describes a complete line of reliable Mylar capacitors which feature high insulation resistance and operating temperatures to 165 C. Text lists 296 part numbers of wrapped and hermetically sealed units together with their capacitance, voltage, and dimensions. Also shown are photographs and dimensions of various case styles, circuit designations, and characteristic curves of capacitance, insulation resistance, and power factor versus temperature. 8 pages. Hopkins Engineering Co., 12900 Foothill Blvd., San Fernando, Calif.

Circle 605 on Page 19

Motor Products

Motor Selector provides in brief, easy-to-use arrangement a quick reference to a complete motor and generator line. AC motors range from 1/40 to 300 hp, and other special motor designs are listed. Brochure also lists horizontal-shaft and right-angle gearmotors, coupled-unit speed reducers, generators, motor-generators, frequency changers, and industrial bench grinders. 8 pages. Howell Electric Motors Co., Howell, Mich.

Circle 606 on Page 19

Fuel Cells

"Some Plain Talk About Fuel Cells," Booklet GED-4111, discusses basic facts about fuel cells including how they work, problem areas, various types of fuel cells under development, special features of the ion-membrane fuel cell, technical performance data, and application information. Photographs, graphs, schematic drawings, and diagrams illustrate the text. 12 pages. General Electric Co., Schenectady 5, N. Y.

Circle 607 on Page 19

Magnesium Alloys

Brochure titled "Magnesium in the Electronics Industry" provides details on light weight, superior damping capacity, availability of elevated-temperature alloys, and other advantages of magnesium. Illustrations of some applications for which magnesium alloys were selected are included. 20 pages. Dow Chemical Co., Dow Metal Products Co. Div., Midland, Mich.

Circle 608 on Page 19

Aluminum Boxes and Covers

Catalog B60 lists over 12,000 standard deep-drawn aluminum boxes and covers for immediate delivery. It also lists standard sizes of rectangular brass and round aluminum boxes and covers. Complete information on sizes and materials is included. 24 pages. Zero Mfg. Co., 1121 Chestnut St., Burbank, Calif.

Circle 609 on Page 19

Adjustable-Speed Drives

Bulletin 101 describes operation and performance of electronic Select-A-Spede drives, ranging in size from ¾ to 4 hp. Principles of operation are explained with the use of a simplified schematic diagram. Three components—electronic control panel, control station, and dc drive motor—are pictured and described. Speed regulation and speed range are discussed. 4 pages. Louis Allis Co., Dept. P, 427 E. Stewart St., Milwaukee 1, Wis.

Circle 610 on Page 19

Printed-Circuit Motors

Two technical data sheets on Model 368 and Model 488 permanent-magnet printed dc servo motors describe in detail the thin, flat printed-circuit armature which replaces the wire-wound armature employed in conventional motors. Complete operating specifications are also included. Charts and other descriptive material outline the speed-torque characteristics of the unit, and listing of applications is included. Printed Motors Inc., 33 Sea Cliff Ave., Glen Cove, N. Y.

Circle 611 on Page 19

Silicon Rectifiers

Four data sheets cover many of the technical aspects of application, heat sink requirements, surge voltage protection, parallel operation, and series operation of silicon power rectifiers. Additional information is included in curves, diagrams, formulas, and charts helpful in the selection and use of silicon rectifiers and rectifier circuits, and in attaining optimum efficiency from them in all applications. Sheets are numbered 6SI-101 through 104. 7 pages. Fansteel Metallurgical Corp., Publications Dept., North Chicago, Ill.

Circle 612 on Page 19

Servo Design

"Servo Design Simplified" describes a simplified procedure and calculations necessary to obtain optimum performance from second and third-order servo systems. Basic requirements for servo performance are covered in a step-by-step procedure. From the information contained are derived all the parameters of the optimum servo system. 4 pages. M. Ten Bosch Inc., Application and Sales Dept., 80 Wheeler Ave., Pleasantville, N. Y.

Circle 613 on Page 19

Self-Tapping Screws

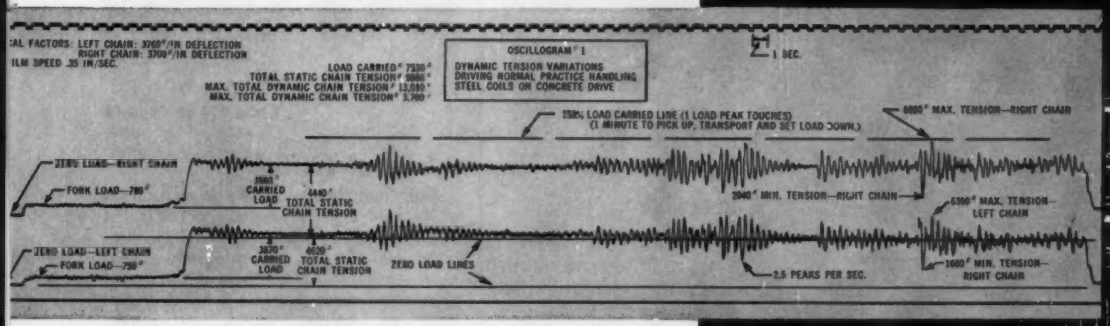
Form 688 provides information on Tapits, screws that drill and tap their own threads. Five major advantages of the units are specified, using a large photograph of the screw to illustrate these. Laboratory test information is also provided, as well as simple installation techniques. 4 pages. Parker-Kalon Div., General American Transportation Co., Clifton, N. J.

Circle 614 on Page 19

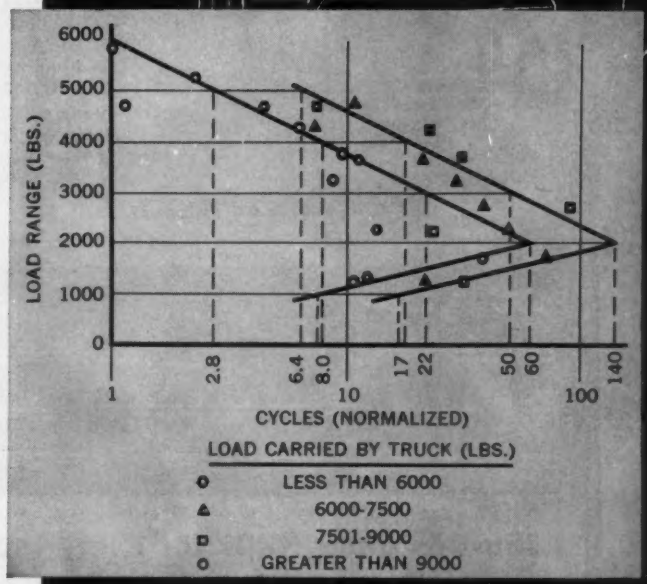
Pace-Setting Research and Development...

Field Dynamic Load Testing Predicts Chain Life

the BIG PLUS value



Oscillogram ... during transportation of load



In the selection and application of chains, machine designers have recognized that fatigue life rather than ultimate strength ratings is the key to correct chain selection. Repeated cyclic stressing causes chain failures even though operating loads are well below the rated ultimate strength of the chain.

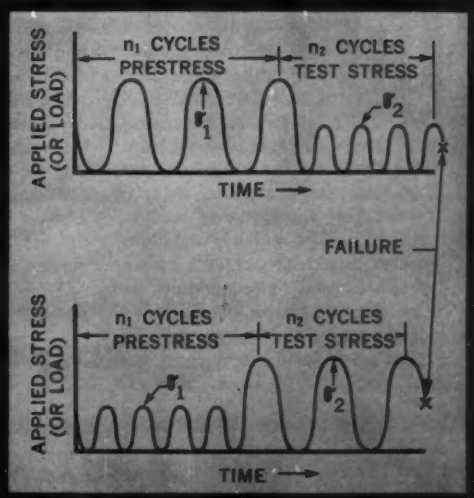
CHAIN Belt engineers are continually developing test data to establish endurance limits and fatigue life ratings for chains and chain parts. These data were used in the design and material selection of Rex Chains. But laboratory conditions cannot always accurately determine the variations in cyclic stressing that occur in many actual applications.

To provide the accurate data required for precise chain selection, CHAIN Belt engineers developed equipment for determining dynamic loading for chains operating in actual service. From this library of field test and laboratory data, actual predictions of chain fatigue life are made and chains are designed to provide maximum resistance to cyclic stressing. Here's just one example:

On a lift truck, subject to abnormal service conditions, chains were giving only three to four months' life. By using strain gauges on the chains during operation and recording actual load patterns on an oscillograph, it was clearly shown that most of the fatigue damage occurred while the lift truck was transporting the load, rather than when picking it up. Cyclic loadings rather than static tensile loadings were causing the failures.

From these data, a chain was designed that has not failed in three years, compared to the previous three months' service.

To assure longest service life for the chains, sprockets, roller bearings, and flexible couplings you specify, we suggest you have a CHAIN Belt sales engineer review your requirements. Write CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wis.



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CHAIN BELT COMPANY

Circle 493 on Page 19

800 to 1 hp favorites for quiet operation, low maintenance and long-life service . . .

From the case of the A. O. Smith Motor Man — a complete stable of integrals that include single-phase models (1-5 hp) or polyphase (1-800 hp). Also a team of fractional-hp motors. All are sure bets to give top performance over the long, long haul.

And there's an A. O. Smith Motor Man near you — chomping at the bit to give you 24-hour action on all parts and service orders.

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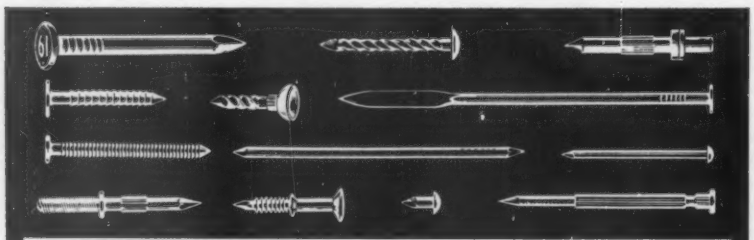
Circle 494 on Page 19



Job-Designed Nails for Every Industry

Here is a fast, dependable, low cost, quality minded source of supply for JOB-DESIGNED nails of all types, in any metal, to fit your own assembly problem. Assembly costs are a very major part of manufacturing expense. Most of this is labor. The fastening medium itself is usually a minimum item. If a Job-Designed fastener makes assembly simpler and faster, permits the use of fewer fasteners, allows the designer functional freedom and improves product efficiency, yours is a specifying job well done. All these possibilities are available when you come to Hassall for design assistance and quotation on challenging, difficult or unusual nails, rivets, threaded parts, drive screws and other cold headed parts. Short or long runs, pilot quantities, engineering counsel, over 100 years of intimate association with cold heading—and a deep appreciation for the concept of value analysis—all are part of the Hassall service to you.

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Circle 495 on Page 19

Sintered Bronze Bearings

Revised Catalog 60-04 details an expanded line of miniature sintered bronze bearings. Included are design features, available styles and sizes, specifications, applications, and installation procedures. Precalculated load-speed rating method of determining allowable bearing loads for any size bearing and any shaft speed is provided. 4 pages. Northfield Precision Instrument Corp., 4400 Austin Blvd., Island Park, L. I., N. Y.

Circle 615 on Page 19

Reinforced Plastic

New bulletin describes the advantages of various types of Scotchply reinforced plastic. Tables present mechanical, electrical, and physical properties, and graphs show mechanical strength versus temperature, stress rupture tensile strength versus time to failure, tensile stress-strain curves, and flexural fatigue curves. 4 pages. Reinforced Plastics Div., Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

Circle 616 on Page 19

Teflon Hose

Industrial Engineering Bulletin IEB-50 contains information on Teflon industrial hose with detachable, re-usable fittings. Cutaway views are provided of the various fittings. Tables provide information on sizes and various assemblies available. Information on adapters, fitting components, and assembly is given. 8 pages. Aeroquip Corp., Jackson, Mich.

Circle 617 on Page 19

Limit Switch

Operating principles of the GO proximity limit switch are given in new bulletin. Unit is described in text and drawing, and several applications are pictured. Installation and operating instructions are provided. 4 pages. General Equipment & Mfg. Co., 116 S. Campbell St., Louisville 6, Ky.

Circle 618 on Page 19

Permanent-Magnet Alloy

Illustrated brochure describes properties and applications of an improved copper-nickel-iron ductile permanent-magnet alloy of the Cunife type. Properties listed include high coercive force and energy product values, excellent ductility, malleability, and machinability. 4 pages. Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.

Circle 619 on Page 19

Variable Transformers

Bulletin SE-L2609 describes motor-driven Powerstat variable transformers which provide efficient, flexible design of systems having loads up to 7.5 kva. Outline dimensions are provided, as well as tables listing electrical characteristics. 4 pages. Superior Electric Co., Dept. MP, 83 Laurel St., Bristol, Conn.

Circle 620 on Page 19

Steel Tubing

Bulletin lists types of seamless tubing available, including low carbon mechanical tubing, low carbon and stainless pressure tubing, aircraft tubing, hydraulic tubing, and stainless-steel tubing. Information on sizes, tolerances, surface finishes, heat treatment, fabrications, and analyses is included. 4 pages. Ellwood Ivins Steel Tube Works Inc., Oak Lane, Philadelphia 26, Pa.

Circle 621 on Page 19

Electrically Operated Valves

Illustrated Bulletin 91024 describes two, three, and four-way electrically operated valves. Bulletin supplies descriptions, specifications, outstanding features, flow charts, optional features, ordering data, and dimensions. 20 pages. Airmatic Valve Inc., 7313 Associate Ave., Cleveland 9, Ohio.

Circle 622 on Page 19

Washers and Stampings

Bulletin includes information on plate, riveting, SAE, narrow-rim, square, standard dock, MIF malleable, OG cast-iron, and beveled washers. All specifications are included. Also included is material on stampings, available in all metals. They can be blanked, pierced, formed, or drawn. 4 pages. Coatesville Plate Washer Co., Coatesville, Pa.

Circle 623 on Page 19

Ball Bearings

Complete engineering information on new Dynamic bearings is available in Engineering Data Sheet D3. Bearings are presently manufactured in sizes from ½ to 1½ in. OD. Information on dimensions, sizes, and design characteristics is included in the data sheet. It also contains low-torque performance data obtained by use of special test and detection equipment. 2 pages. Barden Corp., 200 Park Ave., Danbury, Conn.

Circle 624 on Page 19

Laminated Plastics

Booklet contains information on laminated plastic sheet, tubing, and rod. Sheet includes paper base, mechanical and electrical; canvas, linen, asbestos fabric base; glass and nylon, fabric base; copper-clad sheet for printed circuits. Complete specifications and properties charts are included for each of the various types, and examples of applications are pictured. 16 pages. Dept. SB, St. Regis Paper Co., Panelyte Div., N. Enterprise Avenue, Trenton, N. J.

Circle 625 on Page 19

Magnetic Tape Recorders

Bulletin 55B covers PS-200 line of advanced-design, transistorized, magazine-loading instrumentation tape recorders. Complete specifications and information on new accessories are provided. 8 pages. Precision Instrument Co., 1011 Commercial St., San Carlos, Calif.

Circle 626 on Page 19

Flexible temperature range
-100° F TO 500° F

COHRlastic R-10470 silicone sponge rubber sheets have a dense, uniform, non-absorbing closed cell structure highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications where resiliency at extreme temperatures is required. It may be bonded to metals, plastics, fabrics or silicone rubber. COHRlastic R-10470 possesses superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening.

COHRlastic R-10470 meets: *AMS 3195; AMS 3196; Boeing BMS 1-23; Martin–MMS C451 and MB 6103; Scintilla 9-3143; Bendix ES-0709; Douglas DMS 1597; Lockheed LAC 1-924; Minneapolis Honeywell 6384-3 and Sperry Gyroscope P.691.764 Type HTM.*

AVAILABLE FROM STOCK: in 12″ x 12″ sheets and 24″ x 24″ sheets — 1/16″ through ½″. Special thicknesses and sheet sizes up to 30″ x 30″ and 24″ x 48″ can be made to order. COHRlastic R-10470 is sold nationally through distributors.

CHR PRODUCTS INCLUDE: Airframes and engine seals, firewall seals, and coated fabrics; Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber; silicone cements; conductive gasketing; and Temp-R-Tapes — pressure-sensitive, thermal curing Teflon* Fiberglas and silicone rubber tapes.

FREE SAMPLE and folder — write, phone or use inquiry service.

Leader in Fabrication of Silicone Rubber Products
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Circle 496 on Page 19

HERE'S YOUR ANSWER TO DRIVE PROBLEMS

ATLAS CHAIN
POWER DRIVE CALCULATOR

Get this new slide rule for fast, accurate selection of roller chain and sprockets on all types of drives. Covers service factor and design horsepower . . . the number of teeth required on driving sprocket . . . how to select sprocket size . . . converts length into pitches . . . to length in feet or inches. Combines six "power slide rules" into one handy calculator.

This Atlas calculator is just another step ahead in the field of more efficient power drives by Atlas Chain. There's an Atlas Chain to fit your every need—ASA roller chain, special chains, extended pitch chains, offset sidebar chain, or Flat-Veyor chain . . . plus sprockets and flexible couplings.

Atlas engineers are ready, willing and able to show you how to apply these Atlas products for peak efficiency. Atlas Power Transmission Products include every step to improve your drives and reduce your operating costs. Write today for your free calculator and full data on Atlas Power Products to . . .

ATLAS CHAIN & MANUFACTURING COMPANY
WEST PITTSTON, PA.
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HELPFUL LITERATURE

Circuit Breakers

Rotary-handle circuit breakers and their use in switchboards, control centers, panelboards, and enclosed circuit breakers, are discussed in Bulletin 1425. Features of the rotary-handle mechanism are described fully, and other features, such as space-saving design and simplified installation are also covered. Illustrated with photographs and cutaway drawings, bulletin also explains in detail application and use in various situations. 8 pages. Federal Pacific Electric Co., 50 Paris St., Newark 1, N. J.

Circle 627 on Page 19

Urethane Coatings

Twelve clear urethane coatings are described in Information File 1-60. They are recommended for use wherever varnishes or lacquers have been used previously as finishes or protective coatings. Coatings are described and a chart provides general, physical, chemical, and mechanical properties for each of the twelve types. Suggested applications are included. 4 pages. B. B. Chemical Co., 784 Memorial Drive, Cambridge, Mass.

Circle 628 on Page 19

Control Equipment

Catalog 57-S7 describes accessories and special control equipment, including: Break-glass switches; control stations for mechanically held switches and relays; relay panel for gas valve; engine generator isolating switches; marine-duty transfer switches; phase-sequence correctors. Pictures, wiring diagrams, and specifications are included. 16 pages. Automatic Switch Co., Florham Park, N. J.

Circle 629 on Page 19

Nylon Fasteners

Booklet includes information on screws, nuts, washers, balls, threaded rod, and specials. Specifications and pictures are provided, as well as price information. List of features of the nylon fasteners is included. Nylogrip Products, 570 Pleasant St., Watertown 72, Mass.

Circle 630 on Page 19

Brakes and Clutches

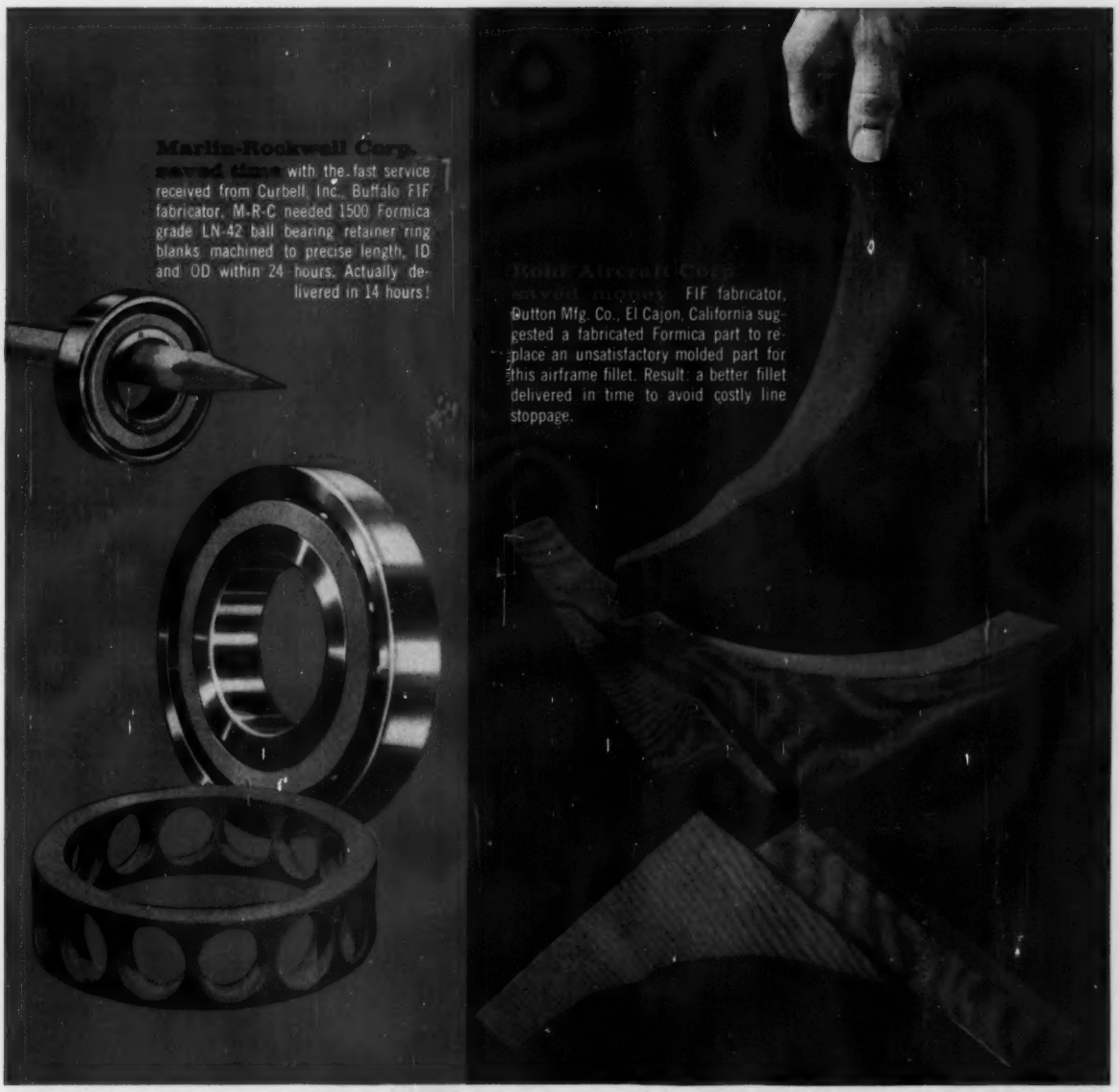
"Tailored Torque" explains operating principles, and describes several clutch, brake, and clutch-brake applications. It outlines specific operating advantages, and includes torque ratings and package dimensions for complete line. 8 pages. Warner Electric Brake & Clutch Co., Dept. P-78, Beloit, Wis.

Circle 631 on Page 19

Multiplexing Unit

Radiplex 89 is the subject of a new brochure. Discussing a wide variety of applications for the unit, brochure includes detailed specifications, block diagram, and photographs. It describes ease of maintenance and versatility of operation permitted by plug-in Radiboards. 4 pages. Radiation Inc., Melbourne, Fla.

Circle 632 on Page 19


Marlin-Rockwell Corp. saved time with the fast service received from Curbell, Inc., Buffalo FIF fabricator. M-R-C needed 1500 Formica grade LN-42 ball bearing retainer ring blanks machined to precise length, ID and OD within 24 hours. Actually delivered in 14 hours!
Rohr Aircraft Corp. saved money FIF fabricator, Dutton Mfg. Co., El Cajon, California suggested a fabricated Formica part to replace an unsatisfactory molded part for this airframe fillet. Result: a better fillet delivered in time to avoid costly line stoppage.

Here's proof new FORMICA® fabricated parts service can save you time and money

Rohr Aircraft, Marlin-Rockwell and many other leading manufacturers now save time and money on the new and dependable parts service offered by their local Fabricators of Industrial Formica laminated plastics.

So can you. Regardless of your location, there's an *FIF fabricator nearby. He's equipped to deliver *all* your fabricated parts faster, simple or complex, in prototype or production quantities. He'll adhere strictly to your blueprint specs, and will give you cost-cutting parts design and materials selection suggestions, too.

So, for *better* parts *faster,* be sure to contact your local FIF fabricator. Phone your Formica district office for his name and address, or write Formica Corporation, a subsidiary of American Cyanamid, 4514 Spring Grove Ave., Cincinnati 32, Ohio.

Free Designer's Fact Book
Brand new concept in the presentation of laminated plastic properties and application data. Valuable aid to designers, production engineers, purchasing agents. Send today for your free copy.

*FIF *This seal identifies your local Fabricator of Industrial Formica. Remember: FIF for the fastest parts service, Formica for the finest laminated plastics.*

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NEW PLASTIC DISCOVERY

Slips on loose... Shrinks with heat

SCOTCHTITE BRAND
HEAT REACTIVE TUBING

Now you can add a tough, smooth protective vinyl covering to handles, levers, tubes, wires, rods, even odd shapes with "SCOTCHTITE" Heat Reactive Tubing. Just slip "SCOTCHTITE" Tubing over object to be covered—apply heat—and almost immediately the tubing contracts to form a skin-tight seamless wrapping. Tools, cables, coils, pipes, and flexible conduit are just a few of the many possible applications. "SCOTCHTITE" Heat Reactive Tubing is available in sizes from 3/64 up to 5¼ inches in diameter. WHAT CAN YOU DO WITH "SCOTCHTITE"? Write for free sample and complete information to: Irvington Division, 3M Company, 900 Bush Avenue, St. Paul 6, Minn., Dept. EBL-70.

"SCOTCHTITE" IS A REGISTERED TRADEMARK OF 3M CO., ST. PAUL 6, MINN.
EXPORT: 99 PARK AVE., NEW YORK 16. CANADA: LONDON, ONTARIO

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Circle 499 on Page 19

Wolverine TOGGLE CLAMPS

Cost Less per Thousand Clamping Operations

Note These Important Features:

- HARDENED PINS and BUSHINGS
- HEAVY BODY SECTIONS
- BLACK OXIDE FINISH
- PINS RIVETED FLUSH
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C-110

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Many Types to Satisfy Your Work Holding Needs

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DETROIT 7, MICHIGAN

CQ-810

C-150

Circle 500 on Page 19

HELPFUL LITERATURE

High-Temperature Motor

HM-420 high-temperature motor with working ambient temperature range from −65 to +600 F is described in Product Bulletin PS-8A. Bulletin contains a photograph of the motor, along with performance curves, outline drawing, general engineering data, and a section on special design features. 4 pages. Airborne Accessories Corp., Marketing Dept., 1414 Chestnut Ave., Hillside 5, N. J.

Circle 633 on Page 19

Military-Use Casters

Military and specialty casters are described in Form 42060. Featured are swivel-plate and rigid-plate casters in single and dual-wheel types. Special features include choice of nine types of metal, plastic and rubber-tired wheels, self-aligning action on dual-wheel casters, double-action springs, and four-position locks. 6 pages. Faultless Caster Corp., Dept. PR-222, Evansville 7, Ind.

Circle 634 on Page 19

Adjustable-Speed Drives

"Type RS P.I.V. Variable-Speed Drives," Folder 2874, describes new constant-horsepower, adjustable-speed drives designed to meet capacity demands to 50 hp and ratios to 5.5:1. Folder describes the new features of a twin-strand single-roll chain that operates between a pair of smooth facing wheels to change the ratio and output shaft speed as effective diameter of the wheel faces is altered. Folder also illustrates types of assemblies and sizes available, gives speed variation ratios and selection data. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill.

Circle 635 on Page 19

Resins for Rubber

Form S-79, "Schenectady Resins for Rubber Compounding and Rubber-Based Adhesives" presents the latest data on properties and functions of resins produced for use in compounding rubber and in formulating rubber-based adhesives. Resins include major types of phenolics, terpene-phenol resins, and pure hydrocarbon polyterpenes. Use of these resins with butyl, natural, neoprene, nitrile, reclained, and SBR elastomers is discussed. Much data are presented in tabular form. Schenectady Varnish Co. Inc., Schenectady 1, N. Y.

Circle 636 on Page 19

Steam Traps

Catalog FE-310 provides detailed information about the complete MIL line of low-cost bimetal thermostatic and flat thermostatic steam traps, available in a wide variety of pressure ranges, body patterns, sizes, and connections. Cut-away views are given for the various types, and operation and advantages of each are pointed out. Tables provide complete specifications. Farris Engineering Corp., MIL Div., 702 Commercial Ave., Palisades Park, N. J.

Circle 637 on Page 19

Adjustable-Speed Drives

Two-color catalog of Zero-Max stepless adjustable-speed drives for fractional-horsepower use lists and pictures typical applications. Operating features and installation suggestions are accompanied by numerous diagrams and tips on power transmission. Details on all types of units, with or without motor, are provided. Charts and diagrams answer many questions on the use of mechanical adjustable speed. 16 pages. Zero-Max Co., 1952 Lyndale Ave. S., Minneapolis 5, Minn.

Circle 638 on Page 19

Thrust Bearings

Catalog PT-659 features detailed engineering data on improved thrust bearings with an average of 30 per cent greater load capacity, and new line of thrust bearings with metric dimensions. Detailed information on dynamic and static bearing capacities, tandem thrust bearings, new sizes of crane-hook bearings, and bearing applications is contained in the publication. Pictures, line drawings, and tables provide all specifications. 28 pages. Rollway Bearing Co., 541 Seymour St., Syracuse, N. Y.

Circle 639 on Page 19

Solenoid Valves

Condensed Catalog D2 includes information on many types of solenoid valves. Cross-sectional and line drawings are provided, as well as all specifications and information on media. Selection guide is included, as well as a list of optional features available. 8 pages. Skinner Electric Valves, New Britain, Conn.

Circle 640 on Page 19

Investment Castings

Catalog 10-59 describes precision components for industrial and commercial applications manufactured by investment casting. Discussion of applications for which investment casting and Minicast processes are best used is included. Fourteen case studies of precision cast parts represent a wide variety of industries. Technical data section includes material on general design features, castable metals and alloys, and tolerances. 8 pages. Casting Engineers, 2323 N. Bosworth Ave., Chicago 14, Ill.

Circle 641 on Page 19

Gears and Gearboxes

New brochure on custom gears and gearboxes contains illustrated information on facilities for precision manufacture and inspection of made-to-order gearing. In addition, material is included on steels used, tables of tooth parts, spur-gear proportions, dimensions for 6 and 10-key spline shaft and fitting, spur-gear correction tables, and hardness conversion table. 32 pages. Request on company letterhead from Cincinnati Gear Co., Wooster Pike and Mariemont Avenue, Cincinnati 27, Ohio.

ASSEMBLE PARTS FASTER . . . WITH FEWER REJECTS!

DPS model U power screwdriving machines

- Maintain constant driving torque with new positive control clutch
- Dependable motorized hopper drive with safety clutch protects motor and gears in the event of jamming
- Release screw by body or head with new feed track and escapement mechanism

Write today for DPS Model U Bulletin

You can drive up to 40 screws per minute with a DPS Model U. Nuts are driven equally fast . . . with accuracy that cuts parts waste, improves assembly quality.

DPS offers the Model U in two types: pedestal, and self-contained driving head. Both require minimum space and are readily adaptable to your work flow. Feed track and escapement mechanism mounts on either side of the machine column for right- or left-hand assembly. The versatile self-contained driving head is ideal for use in automatic assembly machines incorporating dials and straight-line transfers.

The Model U drives screws from #6 x 3/16" long to 1/4" x 1 1/2" long . . . and can be equipped with 12" or 16" barrel feeders.

DETROIT POWER SCREWDRIVER COMPANY
2801 W. Fort St. • Detroit 16, Michigan
A Subsidiary of Link-Belt Company

15,334

Circle 501 on Page 19

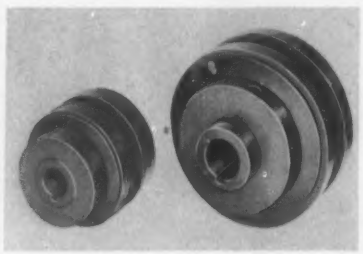
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Friction Clutch

has completely adjustable torque setting

New torque-controlling friction clutch combats distortion by dissipating heat through a one-piece, cast-iron hub and pressure-plate. Torque setting is completely adjustable. Overloads beyond torque setting are "soaked up" by built-in slippage provision. As soon as the



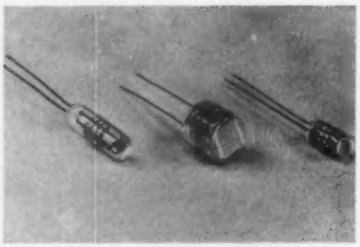
overload is removed, clutch returns to positive drive and connected equipment goes back into operation. Complete range of standard sizes is offered, both for replacement and for original equipment uses. Non-standard sizes are available to specification. **Vickery Div., Norwalk Tool & Die Inc.**, 52 Woodlawn Ave., Norwalk, Ohio.

Circle 642 on Page 19

Photoconductive Cells

for low-voltage applications

Low - resistance photoconductive cells, Type L, are hermetically sealed in glass. Useful in transistor and other low-voltage applications, units are rated at 60 v maximum with a resistance as low as 40 ohms at 100 ft-c. Seven types are furnished, five of the cadmium-selenide variety and two of cadmium sulfide. They provide a choice of resistance, speed, and spectral response to suit most applications. Units also pro-



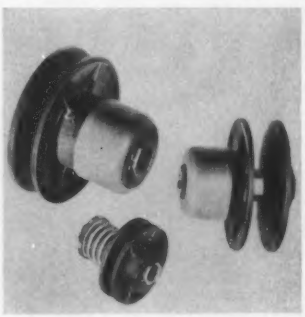
vide a power dissipation range to ½ w continuous, and high ratios of light to dark current even at low light levels. They are available in the three package configurations of the 400, 500, and 600 series, ranging in diameter from 0.25 to 0.5 in. and in length from 0.5 to 1 in. **Clairex Corp.**, 19 W. 26th St., New York 10, N. Y.

Circle 643 on Page 19

Variable-Pitch Pulleys

molded nylon units in all popular belt widths

Expanded VP series of variable-pitch pulleys now includes sizes for ¼, ⅜, and ¼-in. top-width V-belts used in fractional-horsepower drive assemblies and control equipment. Pulleys provide adjustable-speed control within a range of 2.45:1. Three sizes are standard from 1⅞ to 3¼ in. OD, with choice of shaft bores from ¼ to ⅝ in. Pulleys are spring-loaded to maintain required belt tension. Molded of nylon-impregnated glass fiber, pulleys have



extreme chemical and corrosion resistance and are self-lubricating. **Rampe Mfg. Co.**, 14915 Woodworth Ave., Cleveland 10, Ohio.

Circle 644 on Page 19

Low-Carbon Bearing Balls

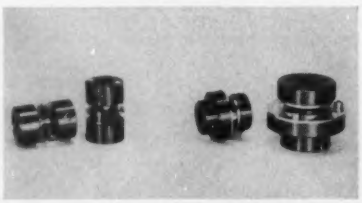
in 1/16 through ⅜-in. sizes

Carburized steel bearing balls are held to AFBMA Grade 50 and Grade 25. Diameter tolerances for balls of these grades are 0.000050 and 0.000025 in. respectively. Balls are SAE 1010-1020 steel carburized and tempered with a resulting minimum surface hardness of Rockwell C 60. Range of sizes initially offered is 1/16 through ⅜ in. **Pioneer Steel Ball Co. Inc.**, Unionville, Conn.

Circle 645 on Page 19

Flexible Couplings

miniature units have no backlash

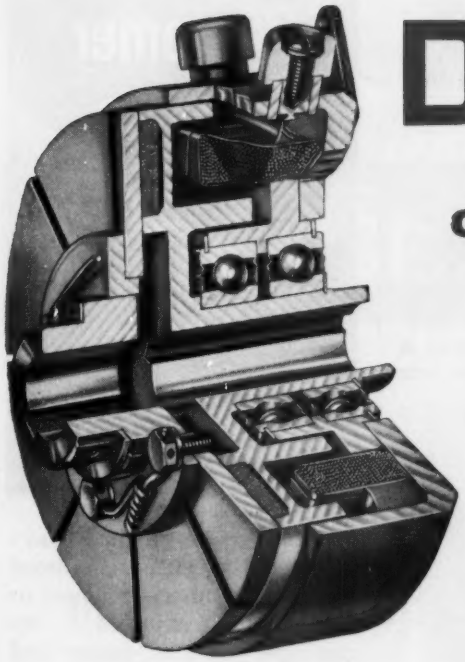


Miniature precision flexible couplings of the instrument type have no backlash, accommodate both lateral and angular misalignment, and are compact and lightweight. Type MPC-1 consists of two flanged aluminum hubs, nylon, or stainless-steel discs with V-grooves that are displaced 90 deg with each other, and are fastened with stainless-steel springs loading the ball pivots against V-grooves. Type MPC-2 consists of two cylindrical aluminum hubs, each having two ball pivots attached. Hubs are attached to a pair of phosphor-bronze flex-

Small Units for Big Jobs!

EATON DYNA-TORQ

MAGNETIC-FRICTION CLUTCHES and BRAKES



STATIONARY-FIELD, BEARING-MOUNTED DYNA-TORQ CLUTCH

Now Available in a Full Line from 1¾" to 15" Diameter

Eaton Dyna-torQ Magnetic-Friction Clutches and Brakes provide a simple, accurate, responsive method of controlling power and motion in today's complex production and processing machines.

The smaller sizes and advanced design types of Dyna-torQ Stationary-Field Clutches and Brakes enable Eaton to offer a well rounded line, including flange-mounted and bearing-mounted clutches, and replaceable-face brakes. Unique features of design and construction result in worthwhile maintenance cost savings. Dyna-torQ units, easily and quickly installed on new machines or existing plant equipment, deliver many highly desirable advantages.

Dyna-torQ Magnetic-Friction Equipment Offers these Important Advantages:

- ★ Accurate power control
- ★ Dependable motion control
- ★ Rapid response
- ★ Easy "built-in" installation
- ★ Low maintenance costs
- ★ Compact plug-in type controls—may be remotely mounted
- ★ Inter-changeability of parts

Send for this illustrated bulletin giving complete description and specifications covering Dyna-torQ Stationary-Field Clutches and Replaceable-Face Brakes.

EATON

Dyna-torQ Equipment is Available through Dynamatic Distributors in all Leading Cities

EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

SPECTROL PRECISION MECHANISMS

The Big Squeeze Job

SPECTROL'S new PRECISION MECHANISM—a velocity servo—is more than just another interesting shrink job. It's useful. It can go anywhere you need an ultra-miniature, precision speed control device.

First, the package. It measures only 1½ x 1½ x 3 inches. In a space that would give a sardine claustrophobia, Spectrol engineers squeezed a solid-state amplifier, a servo-motor, a gear train, and a very special, condensed (½-inch long) potentiometer and switch.

The pot has four electrically isolated wipers, all riding 90° apart on the same coil. The switch, in the same pot housing, has four wipers riding on an alternately conducting and non-conducting surface.

THE FUNCTION: The servo accepts dc signals varying between ±10 v from a computer to drive the pot in such a manner that speed is directly proportional to the dc signals.

THE APPLICATIONS: Here's an example: tied to an airborne computer, the Spectrol servo will drive a scope in the cockpit of one of the nation's hottest aircraft. The object: to give the pilot a visual, three-dimensional analog of his position. Actually, the servo will drive anything—resolvers, synchros, tachs, other pots and switches. It's a complete, ready-to-go package you can put into your system as is.

This is another example of how Spectrol PRECISION MECHANISMS free the systems engineer from building functional subassemblies using components such as gear drives, clutches, precision potentiometers and servomotors. If you need modules combining any of these components in a *single specification*—Spectrol can help.

For more details, call your Spectrol engineering sales representative, or address Dept. 63.

18

SPECTROL

ELECTRONICS CORPORATION
1704 SOUTH DEL MAR AVE. • SAN GABRIEL, CALIF.
Wescon Booth 1004

Circle 503 on Page 19

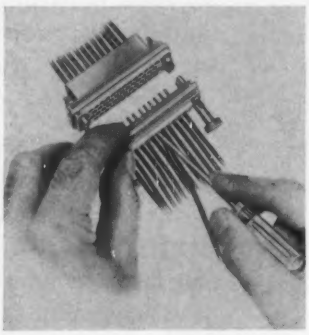
ible discs which captivate and load the ball pivots. Over-all dimensions of MPC-1 are ⅞ x ⅞ in. and of MPC-2, ¾ x ½ in. **Technology Instruments Corp.**, 531 Main St., Acton, Mass.

Circle 646 on Page 19

Miniature Connectors

have removable contacts

Series 2500 miniature rectangular Continental connectors have crimp-termination removable contacts. Contacts have wide, three-tine spring clutch on pin and socket to provide maximum holding area between contact and molded block. Socket and pin contact material is phosphor bronze, gold plate over



silver plate. Connectors are available in 14, 26, 34, 50, 75, and 104-contact sizes with removable contacts for No. 14 to No. 24 AWG wire. Contacts are supplied separately from connector body and wired independently, permitting mounting of connector plug and socket units at any time without waiting for completion of wiring operation. Contacts can be removed quickly and relocated or replaced readily without disturbing connector body. **Electronics Div., DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 647 on Page 19

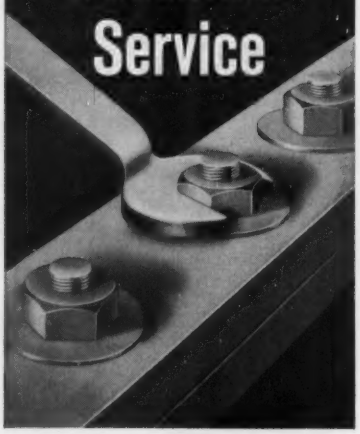
Check Valve

miniature unit is for maximum temperature of 900 F

Miniature in-line check valve is for applications too small to accommodate larger check and butterfly valves. Available in sizes from 0.25 to 0.50 in., valve permits direct coupling into high-pressure, high-tem-

News for HEAVY INDUSTRY...

Tailored Customer Service



Whether you're building heavy machinery, steel mills, railroad cars, construction equipment or other capital equipment . . . we can save you time, money and production problems with *tailored customer service:*

- **tailored** to industry standards or your own specifications . . . impact-form'd heavy duty nuts and bolts
- **tailored** product verification . . . every heat verified in our own laboratories
- **tailored** design recommendations . . . to your application requirements
- **tailored** order service and handling . . . geared to your production schedules
- **tailored** stock plan . . . to reduce your investment

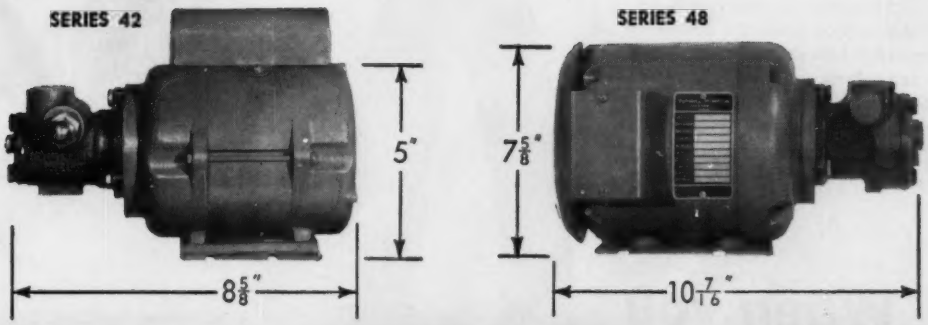
Start now to take advantage of all these services . . . there's no extra cost to you. VMA 6995

SCREW AND BOLT CORPORATION OF AMERICA
P. O. Box 1708 Pittsburgh 30, Pa.

DIVISIONS: *Pittsburgh Gary · Southington Hardware American Equipment*

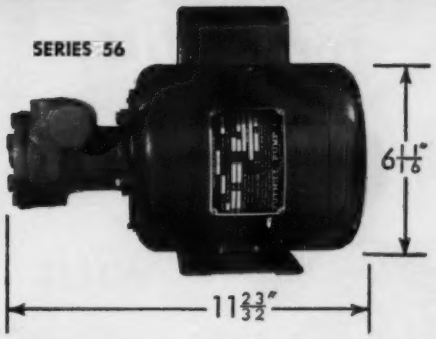
America's Most Complete Line of Industrial Fasteners

Circle 504 on Page 19



SAVE SPACE...WEIGHT...MONEY

with TUTHILL close-coupled pump and motor combinations



Tuthill close-coupled pumps and motor combinations are especially designed for applications where space is at a premium. Their compactness simplifies assembly operations and lowers production costs. Elimination of couplings, bases and adapters results in significant savings . . . and reduced weight means lower shipping costs.

Tuthill offers a complete selection of units with capacities up to 50 GPM for pressures to 500 PSI. A wide variety of special options is also available. Three standard units are pictured above.

Immediately available from stock

The series 42 units measure only 5"x8 5/8". Their total enclosed ballbearing motors are normally supplied with ratings from 1/12 to 1/6 HP while the pump units have capacities of 20 to 45 GPH at 200 PSI.

Series 48 units, measuring 7 5/8"x10 7/16", are normally supplied with totally enclosed, fan-cooled motors of either split phase, capacitor, or 3 phase construction . . . with ratings from 1/4 to 1/2 HP. They can be supplied with pumps with capacities from 20 GPH to 360 GPH at 200 PSI.

Series 56 units measure 6 11/16"x11 23/32", and are offered in a complete range of motors varying from 1/4 to 1 HP. These can be coupled with pumps with capacities from 20 to 360 GPH at 200 PSI.

Although motors are normally furnished for 1725 RPM they are also available for 3450 and 1140 RPM. Explosion proof construction and double shaft extensions on motors are also furnished in series 48 & 56. Built-in relief valves are optional on all five pump sizes.

Special construction for OEM applications

The units shown plus others in Tuthill's line are immediately available without any quantity restrictions whatsoever.

For those original equipment applications involving substantial quantities, Tuthill's engineers can design and build a POWERMITE . . . an exclusive Tuthill design in which pump and motor are combined in one unit which takes up no more space and weighs no more than a standard electric motor. As an example of the compactness possible a Tuthill POWERMITE now being supplied for a hydraulic application measures only 4 3/4"x8 1/16", yet has a capacity of 16 GPH at 350 PSI.

Tuthill's field engineers will be happy to provide details on the complete Tuthill close-coupled line and its application to your particular problem. If you are trying to fit a pump and a motor into a tight space you should talk to them soon. Call today.

Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 GPM; for pressure to 300 PSI; speeds to 3600 RPM.

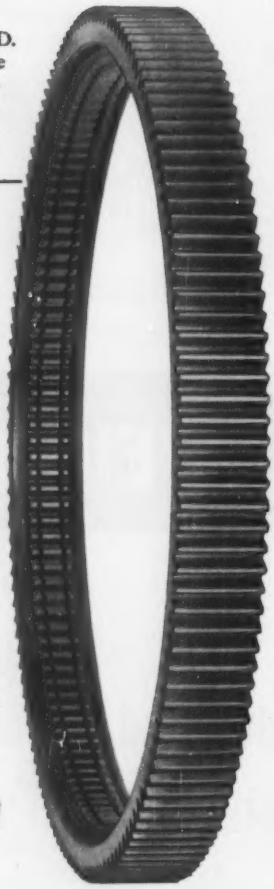
PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

Circle 505 on Page 19

Snap-ring grooves in this 12" O. D. thin-section *Reduction Drive Gear* are machined before carborizing and hardening. Both spline and gear teeth are ground and held to .001" excentricity after hardening the entire gear.



When you DRIVE for profits, GEAR with

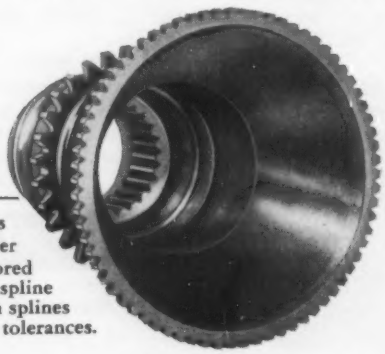
PERKINS

MACHINE AND GEAR CO.

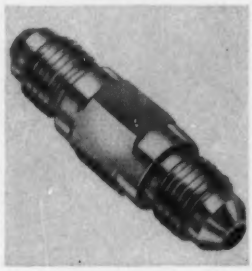
Dept. 83 West Springfield, Mass.

Men who *know* will tell you that custom precision gears made by Perkins can eliminate many design, production and maintenance headaches — literally help you drive for better profits. When you want precision gears in experimental or production quantities, chances are you'll save time and money by checking with Perkins first. What is your gear problem today?

This Handy Gear Calculator, easy to use, saves time. *Folder* illustrating Perkins custom precision gears and facilities offers information. Both yours on request.



Most machining operations on this *Drive Gear Shaft* are performed after localized hardening with the cored areas at Rockwell C42. External spline and gear teeth are ground with splines held to precision tolerances.



perature air-flow lines. It allows air to flow in one direction only and closes immediately upon air flow reversal. Maximum temperature is 900 F with a maximum internal leakage of 0.04 lb per min at 300 psig. External leakage is zero. Weight is 0.12 lb for 0.25-in. valve. **Barber-Colman Co.**, Rockford, Ill.

Circle 648 on Page 19

General-Purpose Adhesive

for metal, glass, insulation, leather

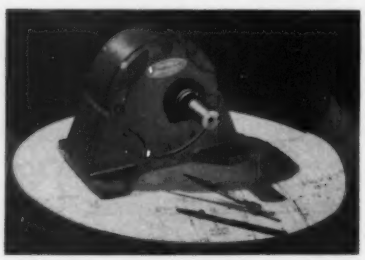
Oil-resistant general-purpose adhesive, Rez-N-Glue 244, is available for clean, strong bonding of wood, felt, cork, insulation, fabrics, leather and some synthetic rubbers to themselves and to metals. Adhesive produces tough bonds that are highly resistant to heat, cold, water, oils, and gasoline. Rubber - base adhesive has viscosity of brush consistency, and is for use without thinning. One gallon coats approximately 200 sq ft. **Schwartz Chemical Co. Inc.**, 50-01 Second St., Long Island City 1, N. Y.

Circle 649 on Page 19

Speed Reducers

in 1/6 to ¾ hp input range

Model 221 Optimount reductors and ratiomotors extend the ratings of helical geared speed reducers to meet increasing needs for drives in



"ALCOA ALUMINUM OFFERS A CHOICE OF TWO SCREW MACHINE STOCK ALLOYS FOR STRENGTH: 2017 AND 2024!"

Precision-made, high-volume screw machine parts cost less in aluminum

Here are the strongest of all Alcoa® Aluminum screw machine alloys. Both will give you superb machinability. Both will give a fine, clean finish. Alcoa Alloy 2017-T4 or -T451 is exceptionally good for deep drilling operations. Alloy 2024-T4 or -T351 offers high shear strength . . . which makes it a popular choice for fasteners and fittings. These alloys will give three times as many parts per pound as other, heavier metals, raise your profits by cutting your over-all unit costs.

Ask your Alcoa distributor or Alcoa sales office for your free *Alcoa Conversion Calculator* . . . which makes cost conversions from brass to aluminum and computes costs quickly . . . and your free *Alcoa Screw Machine Stock Estimating and Operating Data Book*, a comprehensive, easy-to-use book of technical data on aluminum screw machine stock. Get full information on other Alcoa alloys: 2011-T3 or -T8 for faster cutting, 6061-T6 or -T651 for superior finishes, excellent joining characteristics and extra corrosion resistance. Aluminum Company of America, 840-G Alcoa Building, Pittsburgh 19, Pennsylvania.

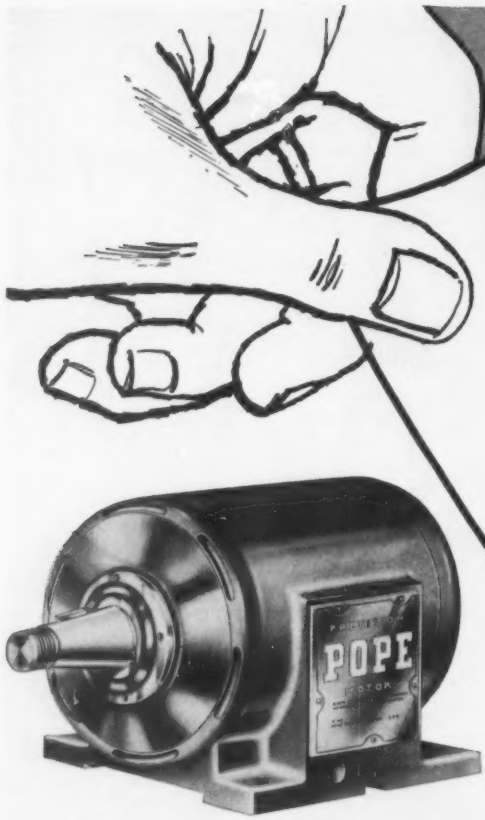
GET ALL THESE BONUSES WITH EVERY ALCOA ALLOY:

1. Wide range of stock sizes for important price advantages.
2. Guaranteed market for up to 60 per cent of your Alcoa Aluminum turnings and borings.
3. Extensive mill and distributor inventory to meet all requirements.
4. Chamfered ends at no extra cost.
5. Specific 12-ft lengths at no extra cost (for rounds up to 2¾ in.; hexagons up to 2 in.).

ALCOA ALUMINUM

SCREW MACHINE STOCK

Circle 508 on Page 19



WANTED

a real PRECISION motor twenty five millionths (.000025) vibration amplitude maximum shaft runout— 75 millionths (.000075)

Now it's here . . .

THE POPE PRECISION MOTOR

Totally Enclosed Fan Cooled Custom-Built

1 to 20 H.P.—900 to 3600 R.P.M.—with straight or tapered shafts

Here is a Precision Driving Motor that has the rigidity and dynamic balance you've always wanted!

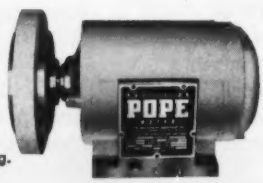
The permanently preloaded double row cylindrical roller bearings with tapered bores are mounted in a heavy section one-piece casting. (There is no front end cover to get out of alignment.)

A pair of extra large precision angular contact preloaded bearings in the rear housing are mounted close to the rotor for extra rigid support of the motor under working loads.

You can make fast convenient wiring connections from the large junction box furnished on whichever side of the motor you specify.

Ask for data sheet SK-306 for outline dimensions and specifications.

Let us quote you on these Precision Driving Motors for use on all your equipment where a real Precision Motor is required.



One of the new Pope Precision Motors equipped with a Pope balancing type wheel holder for precision grinding.

No. 130

POPE®

ENGINEERS, DESIGNS AND BUILDS PRECISION ANTI-FRICTION BEARING SPINDLES FOR EVERY PURPOSE

POPE MACHINERY CORPORATION • 261 RIVER STREET • HAVERHILL, MASS.

Established 1920

Circle 509 on Page 19

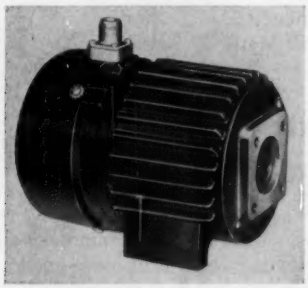
the lower power range. Size 221 is available horizontal, vertical, or shaft-mounted to meet any mounting conditions. New Products Dept., Boston Gear Works, Quincy 71, Mass.

Circle 650 on Page 19

DC Motors

with shunt, compound, or series windings

Three models of low-voltage dc motors in frame size 4636 are available for general use and can be obtained with or without radio suppression. Windings are shunt, compound, or series type. Typical ratings are 1/6 hp, 3500 rpm, 12 or



24 v dc; ¼ hp, 2100 rpm, 12 or 24 v dc; and 1/3 hp, 3600 rpm, 24 v dc. Each motor has a 5½-in. frame diam and weighs about 14.5 lb. Motors have totally enclosed, nonventilated or totally enclosed, fan-cooled, cast-aluminum housings and are equipped with ball bearings. Mountings include pad base and face type. Universal Motor Div., Robbins & Myers Inc., Springfield, Ohio.

Circle 651 on Page 19

Instrument Tubing Harness

for high-temperature operation

Poly-Cor instrument tubing harness features all-black polyethylene core tubes that permit operation at higher temperatures than have been possible previously with all-plastic harness of this type. Black polyethylene has high ultraviolet resistance that eliminates tube deterioration from this source. Core tubes are tightly wrapped with Mylar tape and covered by an extruded vinyl sheath. Construction prevents penetration by vinyl plasticisers, protects against external

now!

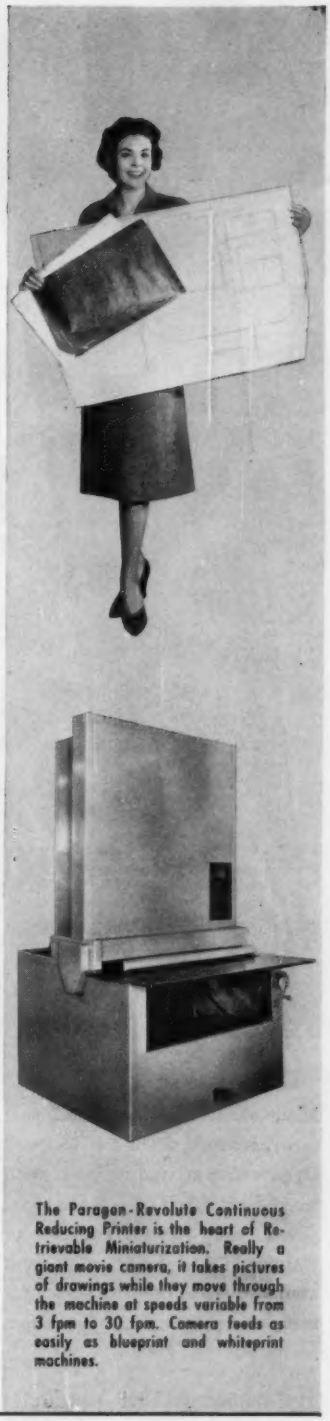
try Retrievable Miniaturization for size in your reproduction department!

THE IDEA. Retrievable Miniaturization is a new ingenious method for reducing the size of prints yet keeping them large enough to be completely readable and usable. Developed by Paragon-Revolute, this method is acknowledged as one of the significant advancements in reproduction.

HOW IT WORKS. In Paragon-Revolute's unique Continuous Reducing Printer and Processor, reduced-size transparencies are made from original drawings for immediate reproduction in blueprint or diazoprint equipment. Reductions can be made as positives or negatives on paper or film. The Printer takes drawings up to 42" wide by any length at speeds up to 30 fpm.

THE ADVANTAGES. Retrievable Miniaturization fits in with existing facilities, calls for no drastic changes in present drafting standards or printmaking systems. It enables savings in materials up to 300% . . . increases capacity of blueprint or diazo-type equipment up to 4 times . . . slashes print handling time, filing space, and mailing costs. Most importantly, it provides readable, usable reduced-size prints without the problems and high cost of blow-back systems.

You owe it to yourself and your company to investigate the advantages and savings offered by this great new concept in reproduction. Use the coupon to get more information or to arrange for demonstration.



The Paragon-Revolute Continuous Reducing Printer is the heart of Retrievable Miniaturization. Really a giant movie camera, it takes pictures of drawings while they move through the machine at speeds variable from 3 fpm to 30 fpm. Camera feeds as easily as blueprint and whiteprint machines.

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☐ Please send me more information about Retrievable Miniaturization.

☐ Please arrange for one of your representatives to contact me about a demonstration.

Name_____Title_____

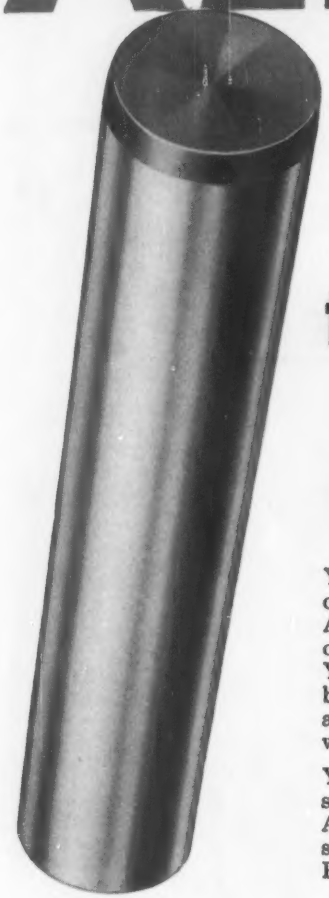
Company_____

Address_____

City_____State_____

Circle 510 on Page 19

ALLEN

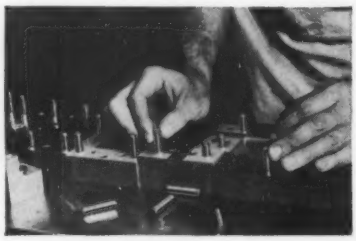


ALLEN is the dowel pin that gives you PLUSES!

Your ALLEN Industrial Distributor can show you a good many ways to use ALLEN Dowel Pins, in addition to conventional uses in tool and die work. You can use them as economical roller bearings, axles, precision plugs, hinge and wrist pins—and in many other ways.

You can cut the cost of your product substantially, too—because your ALLEN Distributor can supply these strong, accurate, mirror-finished Dowel Pins in standard sizes right from stock.

Made of special Allenoy steel; surface hardened to 62-64 Rockwell C; precision ground to .0001" with micro-inch finish of 6 RMS max. Check your Allen Handbook or Catalog for detailed specs and standard sizes, or write direct for samples and technical information.



Genuine ALLEN products are available only through your ALLEN Distributor—he's always ready, willing and able to give you prompt, practical service.

50 ANNIVERSARY YEAR ALLEN HEAD 1910-1960

ALLEN MANUFACTURING COMPANY

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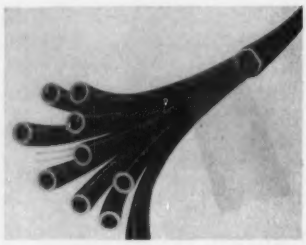


penetration of chemical agents, keeps tubing bundle flexible and lightweight for easy installation, and provides a high degree of physical protection against impacts. Tubes are number-coded in white ink. Poly-Cor is available in 11 core-tube combinations from 2 to 37. Normal sizes for tubes are 1/4 in. OD x 0.040 in. wall, and 3/8 in. OD x 0.062 in. wall. **Dekoron Products Div., Samuel Moore & Co.**, Mantua, Ohio.

Circle 652 on Page 19

Switching Transistor

germanium-alloy unit is for high-speed uses

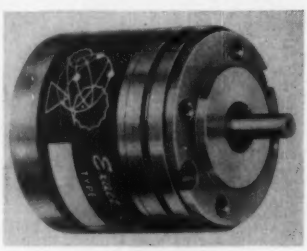
Type 2N404A germanium-alloy switching transistor, designed for high-speed computer applications, is interchangeable with 2N404 military prototype, but excels it in voltage, current, and heat characteristics. Maximum ratings at 25 C include: Collector-to-base voltage of 40 v, junction temperature of 100 C, collector current of 200 ma, and power dissipation of 150 mw. **Sylvania Electric Products Inc.**, General Telephone Bldg., 730 Third Ave., New York 17, N. Y.

Circle 653 on Page 19

Servo Gearhead

miniature unit provides ratios from 3.08:1 to 16,384:1

Model E11 high-precision miniature servo gearhead is for use in servomechanisms and other electromechanical systems which demand

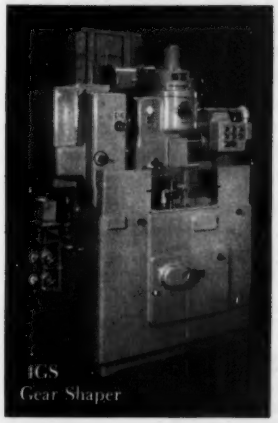


Circle 511 on Page 19

INVOLUTE GEARS

NON-INVOLUTE PARTS

FELLOWS GEAR SHAPERS DO DOUBLE DUTY



1GS
Gear Shaper

Fellows Gear Shapers are not limited to the production of gears alone. They are valuable production machines ideal for the manufacture of many types of parts, of both involute and non-involute form.

As gear shapers, they provide high production rates in the manufacture of internal and external spur and helical gears. As general purpose production machines, they also make possible the economical production of irregularly shaped parts . . . in many cases doing in one simple operation what would require several operations using conventional shop tools.

Your Fellows representative will gladly give you the facts on how the complete Fellows line of production and inspection equipment helps increase production and cut costs. Ask him, or write direct.

THE FELLOWS GEAR SHAPER COMPANY 78 River Street, Springfield, Vermont, U.S.A.

Branch Offices: 1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N.J.
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Gear Production Equipment

...with torque that's terrific

This Jack & Heintz motor is the perfect power package for laundry equipment, air wall ventilators, machine tools, pumps. (You'll find it right now on every major make of floor polisher.)

We can modify it to fit *your* specs, and add such specials as an exterior contour and finish to match the styling and color you've designed for the original equipment. Externally or internally mounted capacitor (¼ through 1½ hp—or higher ratings on request). Single or dual voltage, single or three-phase, special current characteristics. With or without special face or flange-mounting end frames.

We'll design and produce, to your specs:

- complete motor
- ¾ motor kit (rotor, stator and switch end bell)
- motor kit (rotor and stator)

WRITE TO:

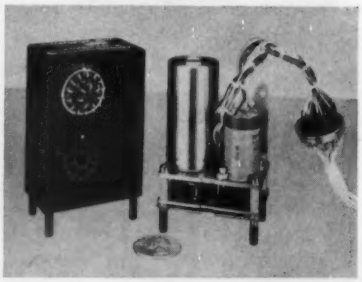
JACK & HEINTZ, Inc.
COMMERCIAL MOTOR DIVISION
17626 Broadway • Cleveland 1, Ohio

high accuracy. It provides almost 1000 different ratios from 3.08:1 to 16,384:1, obtained by using from two to seven gear stages and a motor-output pinion with either 10, 12, 13, or 15 teeth. Gearhead is designed primarily for mounting to a standard size-11 motor. Feature of the gearhead is the incorporation of an integral output spur and output shaft, with output shaft fully supported between bearings. Output torque is 25 oz-in. continuous, and starting torque is 0.015 oz-in. maximum. Backlash through the gear train is less than 45 min for the two-stage unit, and less than 30 min for all other units. Maximum weight is 3.820 oz. **Exact Engineering & Mfg. Co.**, Oceanside, Calif.

Circle 654 on Page 19

Synchronizer Drive

miniature unit has high accuracy



Within a small package, 2.2 x 1.4 x 3 in., are contained a control transformer, motor generator, and two high-quality signal switches (which serve the timing function), all tied together by a precision gear train. Unit weighs less than 1 lb. Backlash in the gearing is 6 minutes max and gearing is 96 pitch, precision 2 stainless steel. **Clifton Precision Products Co. Inc.**, 9014 W. Chester Pike, Upper Darby, Pa.

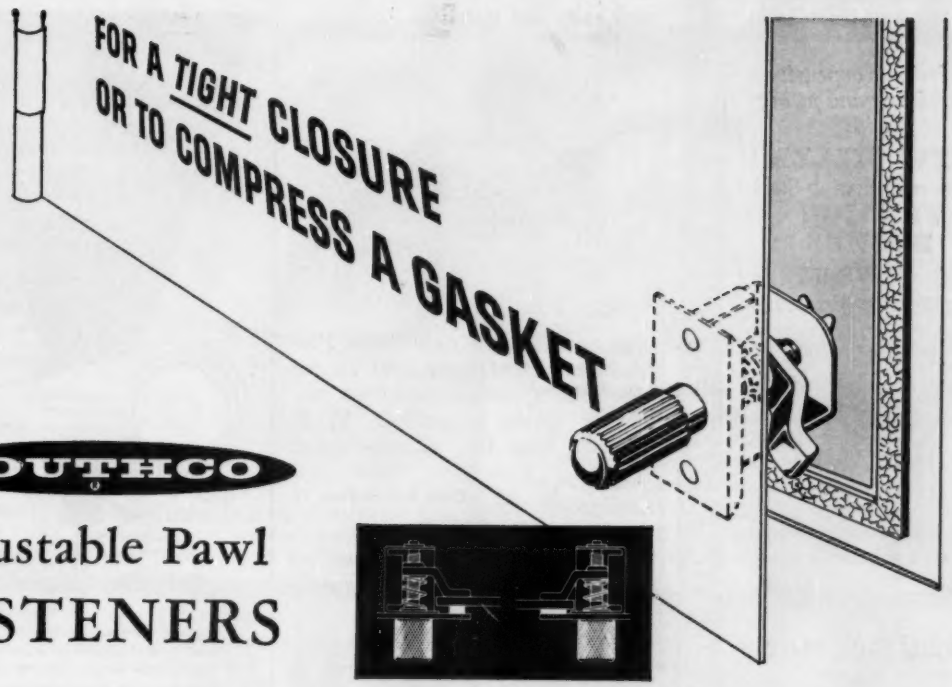
Circle 655 on Page 19

Rigid Couplings

for shafts from ½ to 5-7/16 in.

Five sizes of Sure-Grip rigid couplings, No. 44, align and rigidly connect two shafts of diameters from ½ to 5-7/16 in. Shafts are clamped by interchangeable tapered bushings which provide the equivalent of a shrink fit when they are

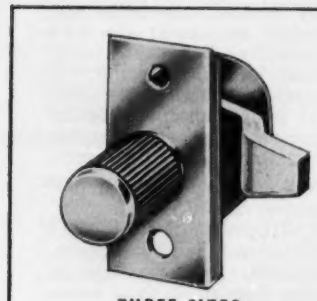
Circle 513 on Page 19



SOUTHCO

Adjustable Pawl FASTENERS

¼ turn closes—additional turning tightens



Just slip the knob through a hole in the door (any door thickness—it doesn't matter). Fasten with two rivets, bolts, or welds. The Southco Adjustable Pawl Fastener will fit your door frame, even when material gauge varies between units.

Turn the knob. The first quarter turn latches the door. Now keep turning. You're pulling the door tightly against its frame. You can compress a gasket, form a dust or moisture seal, overcome vibration.

You'll save installation time and satisfy your customers with these rugged, attractive, pre-assembled fasteners. Ideal for heavy machines, electronic consoles, miniaturized units, cabinets, missiles, slide-mounted modules, etc.

FREE!
FASTENER HANDBOOK
Send for your free copy of Southco Fastener Handbook. Gives engineering data on many fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

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SOUTHCO FASTENERS

LION

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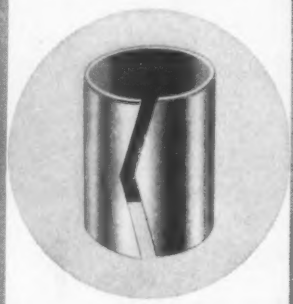
Eliminate expensive machining and fitting with

NEW GILLEN
Hardened Spring Steel
TENSION BUSHES

Self-Seating • Self-Fitting
Long Wearing • Economical

STRAIGHT SLOT



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Internal or External Types
Many lengths and diameters.
Chamfered for
Quick and Easy Insertion.

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EVERY TYPE OF KEYING AND PINNING DEVICE FOR PRODUCTION ASSEMBLING
PIVOTS • BUSHES • TENSION, TAPER, GROOVE & DOWEL PINS • MACHINE KEYS & PARTS

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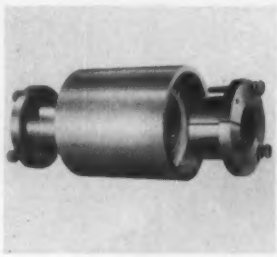
Circle 515 on Page 19



tightened into the rigid sleeve. Precision-machined taper lines up the two shafts automatically as the proper torque is applied. **T. B. Wood's Sons Co.**, Chambersburg, Pa.

Circle 656 on Page 19

Miniature Switch

for use in rotary applications

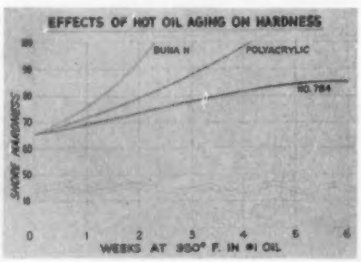
Miniature switch with overtravel plunger for cam actuation in rotary applications is designated B-2PD. Switch has electrical and environmental characteristics which meet the requirements of MS-25085. It is available with drilled single or double-turret terminals. Switch is 25/32 in. long, 1/4 in. thick, and 0.871 in. high. Specifications include overtravel of 0.060 in. minimum, pretravel of 0.015 in. maximum, and operating force of 10 oz maximum. Return force is 1 oz minimum, and movement differential is 0.001 in. maximum. **Milli-Switch Corp.**, Gladwyne, Pa.

Circle 657 on Page 19

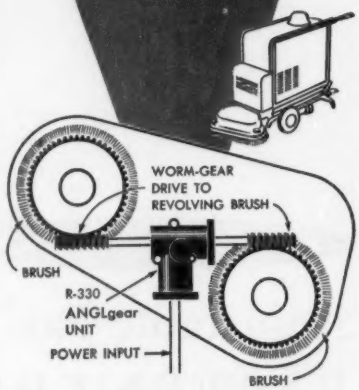
Gasketing Material

for hot-oil applications

No. 784 gasketing material is a Buna-N rubber compound that performs well in oil up to 350 F. It has a wider range of useful life between low and high temperatures than some polyacrylic materials now being used in similar applications.



ANGLgear simplifies power-brush drive



Cutaway shows use of 1 hp ANGLgear in brush head of LAWLORmatic 26 in. electric floor scrubber. Company employs ANGLgear in several of its other models as well.

S. C. Lawlor Co., Chicago, Ill., selected ANGLgear 90° drives for the scrubber/buffer heads of its power floor cleaners for these reasons: (1) compactness—helps cut weight and bulk; (2) high capacity—hardened bevel gears transmit more hp; (3) permanent lubrication—saves on maintenance; (4) sealed housing—eliminates possible fouling by wax or detergents.

If you have a similar 90° power take-off requirement, ANGLgear probably offers the simplest, most economical solution. Available immediately from stock, these standardized right-angle drives are easily incorporated in your power transmission systems* because of their compactness and universal mounting feature.

**Design templates free on request*

You can specify ANGLgear in 1/3, 1, 2 1/4 and 5 hp ratings with 1:1 or 2:1 gearing and 2 or 3-way shafting. See Sweet's Product Design File or our local distributor.

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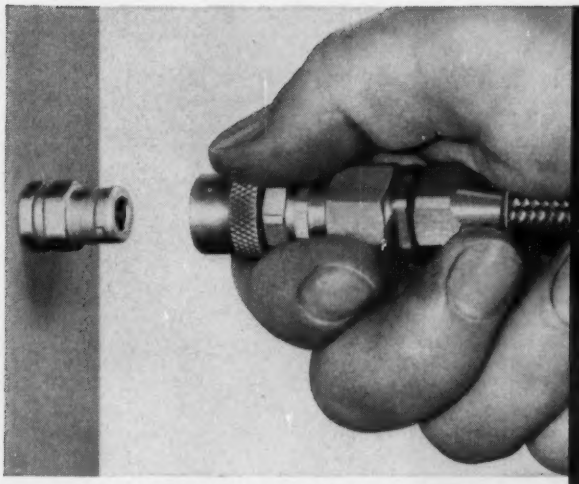
Engineered Equipment for Aircraft and Industry
AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 516 on Page 19



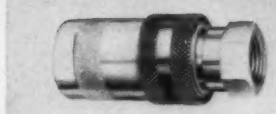
This miniaturized Self-Sealing Coupling on an Aeroquip Teflon Hose Line assures fast, leak-proof connections on the coolant system of an electronic unit.

Aeroquip's Wide Range Of Self-Sealing Couplings Improves Connections On Any Fluid System

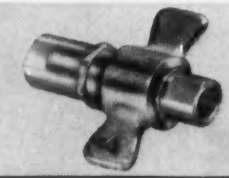
Aeroquip has developed hundreds of Self-Sealing Couplings for standard and specialized applications. Whatever your requirements, there's an Aeroquip Coupling, or a modification, which will provide better fluid line connections and disconnections.

For assistance in solving special problems, Aeroquip's large and long-experienced Engineering Staff is at your service. Mail the coupon below for information.

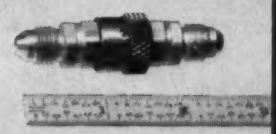
5600 Series PUSH-PULL Coupling provides quick connections on hydraulic, lube oil, air and water lines. It is available for ⅛" to 1" hose lines at working pressures up to 3000 psi.



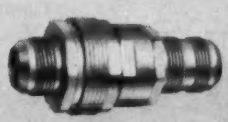
5100 Series Threaded Coupling for a wide range of applications where connection under pressure is required. Available for ¼" to 2" hose lines with pressures to 3000 psi., depending on size.

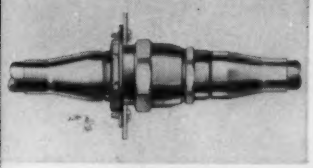


1010 Series Miniaturized Coupling is designed for connections in confined areas. Precision-built, lightweight (.037 lbs.) and compact, it fits ¼" O.D. tube size.

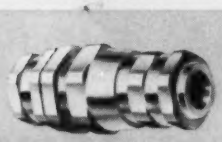


3900 Series PUSH-PULL Coupling combines leak-proof operation with quick, easy connections. Available in sizes up to 1½", it may be used with many low lubricity fluids.

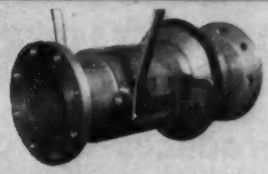




5500 Series Refrigerant Coupling permits precharging and storage of components for remote package units. It is available in sizes from ¼" to 1⅛" O.D. tube sizes.



5400 Series Refrigerant Coupling simplifies assembly line installation of precharged automotive air conditioning systems. Available in O.D. tube sizes from ¼" to 1⅛".



Series 5900 QUICK-LOADER Marine Coupling connects and disconnects quickly to provide fast transfer of liquid cargo without spillage. Sizes for 6" to 12" lines.

Series 510038 Railroad Coupling for Aeroquip Automatic Fueling Unit eliminates fuel spillage or overflow. Coupling feeds fuel quickly, float attachment for automatic shut-off available.

QUICKLOADER and PUSH-PULL are Aeroquip Trademarks.

Aeroquip

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA

AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Aeroquip Corporation, Jackson, Michigan MD-7

☐ Please send me information on the following coupling types:

_____

☐ Please have an Aeroquip Sales Engineer contact me.

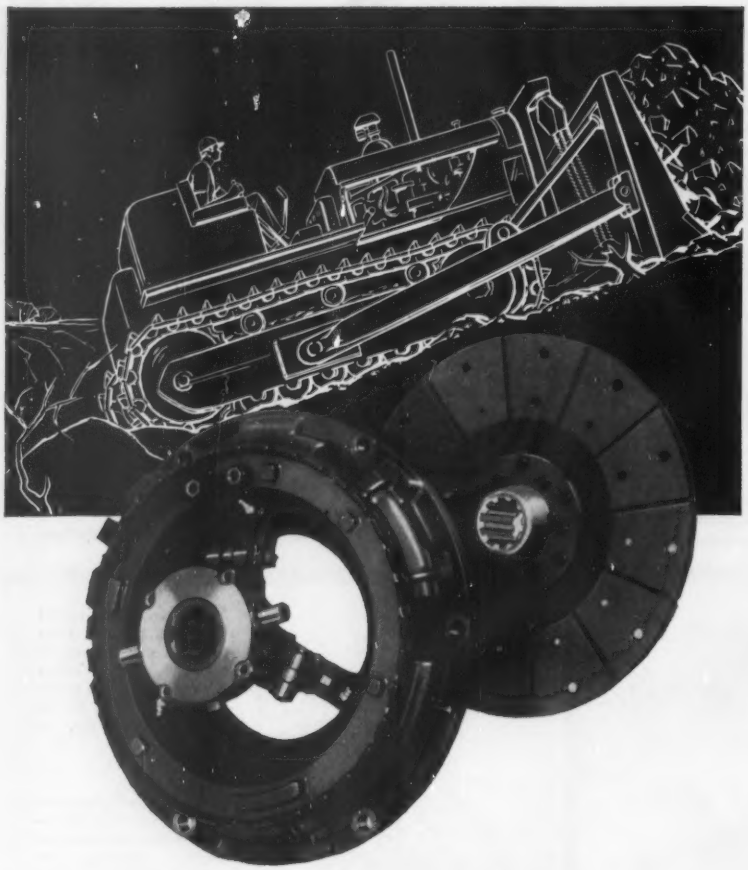
Name_____

Title_____

Company_____

Address_____

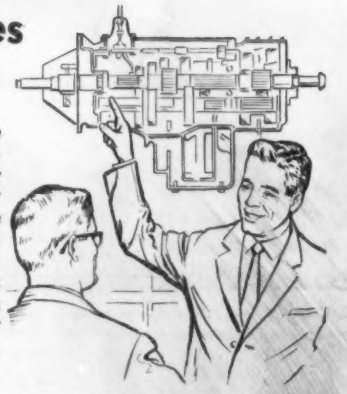
City_____ Zone____ State_____



BETTER COMPONENTS... BETTER PRODUCTS!

Cooperation produces the final design

When each component part is the best, the whole machine is right. Rockford Over-Center Clutches are the finest made for crawlers, cranes and other heavy-duty equipment. If your equipment is in the design stage, let Rockford Clutch engineers help you select the best clutch. Rockford Clutches in standard sizes suit almost every need. Custom models can be designed for your applications. Call or write for the Rockford Clutch Catalog.



ROCKFORD CLUTCHES

ROCKFORD CLUTCH DIVISION BORG-WARNER

311 CATHERINE ST.
ROCKFORD, ILLINOIS

Export Sales
Borg-Warner International
36 So. Wabash, Chicago, Ill.

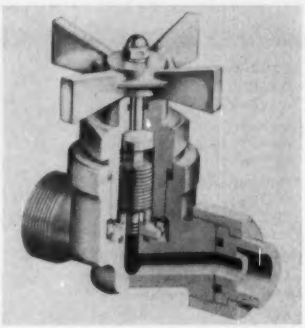
Among the applications for the material are automobile transmission seals and oil seals. **Armstrong Cork Co.**, Lancaster, Pa.

Circle 658 on Page 19

O-Ring Sealed Valves

can be closed by hand with bubbletight shut-off

O-Seal valves and fittings for 6000 psi liquid or gas service operate at temperatures from −20 to +275 F and are available in standard piping sizes from $\frac{1}{4}$ to 2 in. Globe, angle, needle, check, and relief valves are included. Valves can be closed by



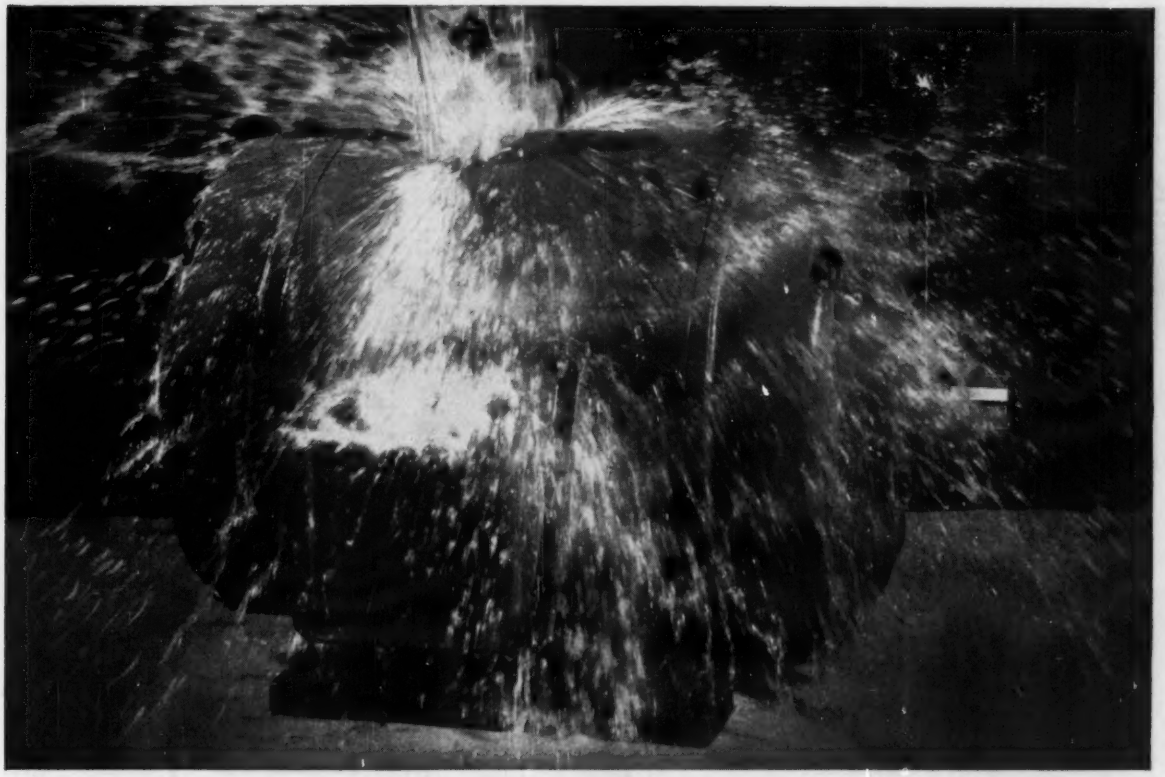
hand with full assurance of bubble-tight shut-off, even of gases, regardless of pressure. Units incorporate relatively soft nylon disc and removable flat Monel valve seat. Smooth-faced valves can be installed or removed without springing the line. O-ring recessed in the face of each tailpiece secures a positive seal between static metal surfaces. Vibration, line surges, or temperature changes do not offset seal. **Combination Pump Valve Co.**, Dept. 109, 851 Preston St., Philadelphia 4, Pa.

Circle 659 on Page 19

Panel Instruments

have 2½-in. diameter

First in a series of panel instruments for commercial applications, Model 25 is a 2½-in. diam unit with an expanded scale plate, providing greater readability and improved reliability. Featured also is a self-shielding internal core magnet with greater torque, eliminating the need for special calibrations when mounting on magnetic or non-magnetic panels. All models



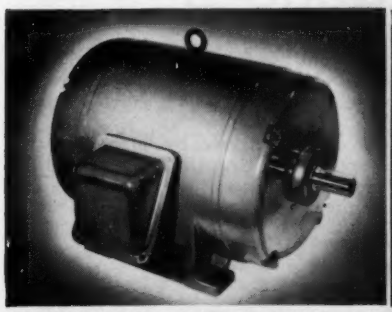
Sudden Splash or Soaking Shower

won't stop a Wagner® DP Motor . . .

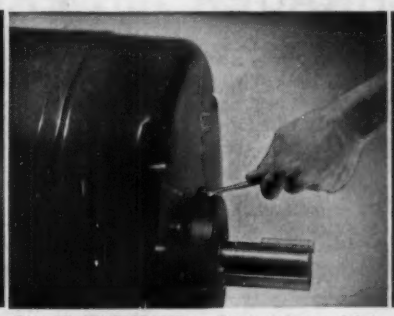
Wagner® Type DP Motors are doubly protected by rugged, corrosion-resistant cast iron frames and dripproof enclosures. Splashing or falling liquids, corrosive acids, salts, and alkalies can't stop their smooth operation. Designed to meet a wide variety of applications—including many that used to require splashproof motors—Wagner Doubly Protected Motors pack plenty of power into precious little space, are lightweight, long-lived, and pare downtime and upkeep costs to the bone. Simply put . . . they get the job done. Let your nearby Wagner Sales Engineer show you how these motors can be applied to your needs. Call him, or write for Bulletin MU-223.

Wagner Electric Corporation

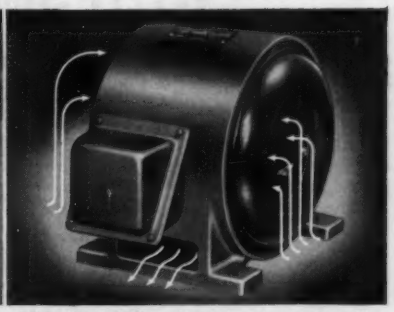
6404 PLYMOUTH AVE., ST. LOUIS 33, MISSOURI



SLEEVE BEARING MODELS AVAILABLE . . . DP Motors are built in NEMA frame sizes 182 through 445U; 1 through 125 hp—1750 RPM—40°C; available with ball bearing construction as illustrated or steel-backed, babbitt-lined sleeve bearings. Larger motors (Type RP) are available through 1000 hp.



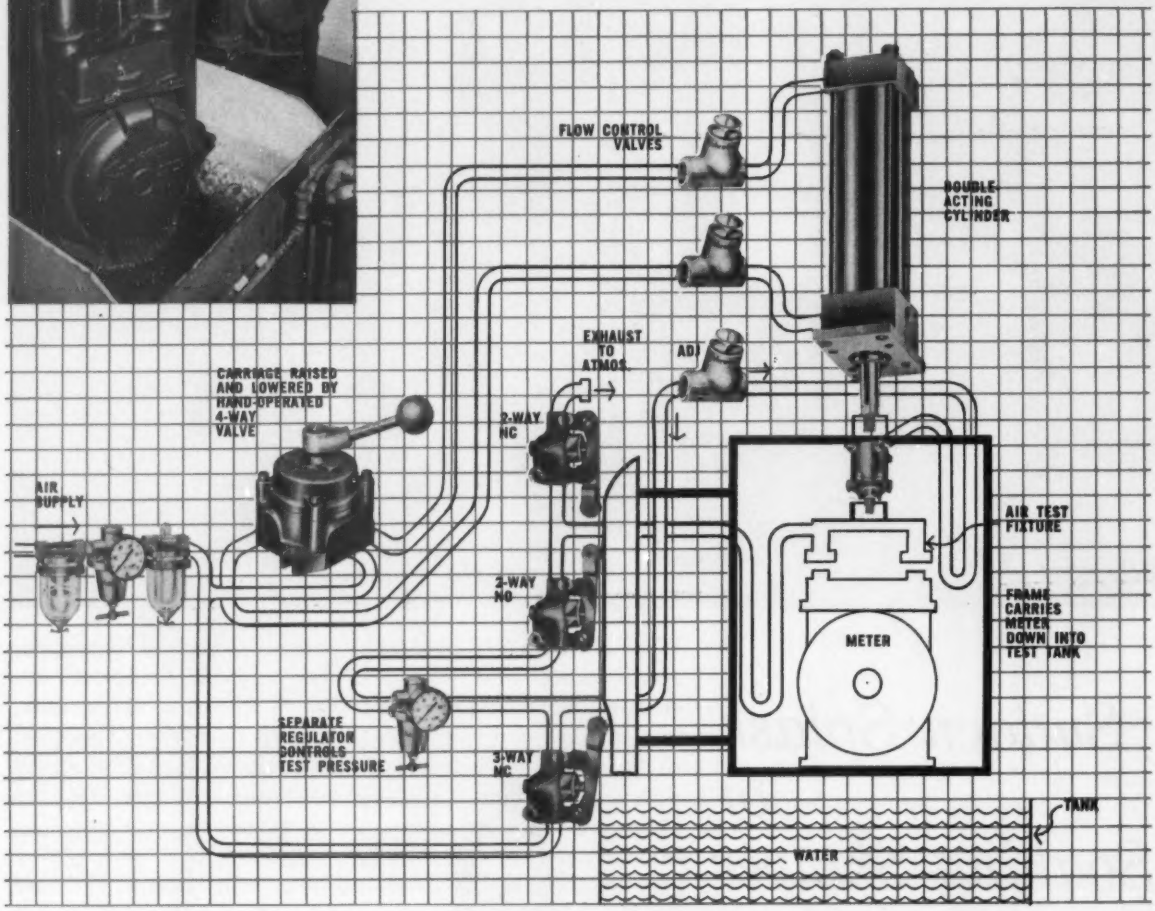
CAN BE RELUBRICATED . . . Original factory lubrication will last for many years in normal service, but openings are provided to permit the relubrication that adds years to motor life under severe conditions.



COOL RUNNING . . . Specially designed baffles direct cooling air through the motor to reduce stator temperature, thus increasing motor life. Blowers, cast as part of the rotor, move large volumes of air without noise or vibration.

WM60-20

Here's how one company tests its products with air. This air circuit of Schrader Products at the Sprague Meter Company in Bridgeport, Connecticut, automatically clamps meter ports airtight, lowers meter into water, and fills it to test pressure. Operator looks for telltale bubbles from leaks, then presses lever to raise meter automatically. Says the Plant Manager: "This used to be a slow, arduous process. Now a meter's in the water, under pressure, in less than a second."



MANUFACTURER SETS UP CRITICAL TEST IN LESS THAN ONE SECOND— WITH SCHRADER AIR PRODUCTS

As products grow more complex and precise, many manufacturers are *simplifying* their operations—with air cylinders, valves, fittings and simple schematic planning. They're installing their own circuits, as this manufacturer did, or letting Schrader experts help. For example, Schrader Air Products can inspect, test, assemble, package—do work faster, more accurately—save effort and money.

Never forget air can make almost any motion human hands can—push, pull, hold, position, or move repetitively. And air doesn't get tired—has more powerful muscles. Maintenance? Almost nil.

Take full advantage of your air power by automating with Schrader—the most complete line of Air Cylinders, Valves, and Accessories. Schrader engineers have experience and know how to help you cut your operating costs.

Select your automating equipment from the full Schrader line. Your Schrader distributor can help you pinpoint what you need. For more data, write:

Schrader®
a division of SCOVILL

A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

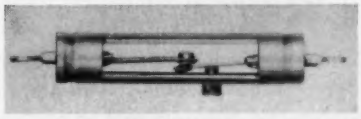
are available as microammeters, milliammeters, ammeters, and voltmeters in a variety of ranges. All models have an external zero adjuster. Various color trim is available on case and scale plate to match associated equipment. **Electronics Div., DeJur-Amsco Corp.,** 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 660 on Page 19

Miniature Thermostat

has maximum differential of ½ deg C

BW ¼-in. diam insulated thermostat has patented wiping action and is available with contacts that open or close with temperature rises. Models can be factory calibrated or externally adjusted to obtain desired actuating temperature, which is unaffected by ambient temperatures. Bimetal-actuated contact is insulated from the case by means of two glass-seal solder terminals and a ceramic tip pressed into ad-



justment screw. Model is recommended for applications requiring minimum differential consistent with contact rating. Maximum differential is ½ deg C. **Chatham Controls Corp.,** 156 River Rd., Chatham, N. J.

Circle 661 on Page 19

Silicon Diode

has low reverse leakage and high switching speed

No. 1N661A silicon diode combines low leakage specifications of best general-purpose types with switching speed of best computer types.

RADIATION CONTROL

AccuRay® instrumentation is based on the radiation of gamma rays from a source unit containing radium-226 or cesium-137. Source units are effectively shielded by housings cast in Meehanite by Hamilton Foundry. The density, and soundness of Meehanite castings provide the positive protection essential for safe and reliable instrumentation.

When buying castings, the skill and integrity of Hamilton Foundry is your best insurance that specifications—and delivery schedules—will be met.

**AccuRay is the registered trade mark of Industrial Nucleonics Corporation*

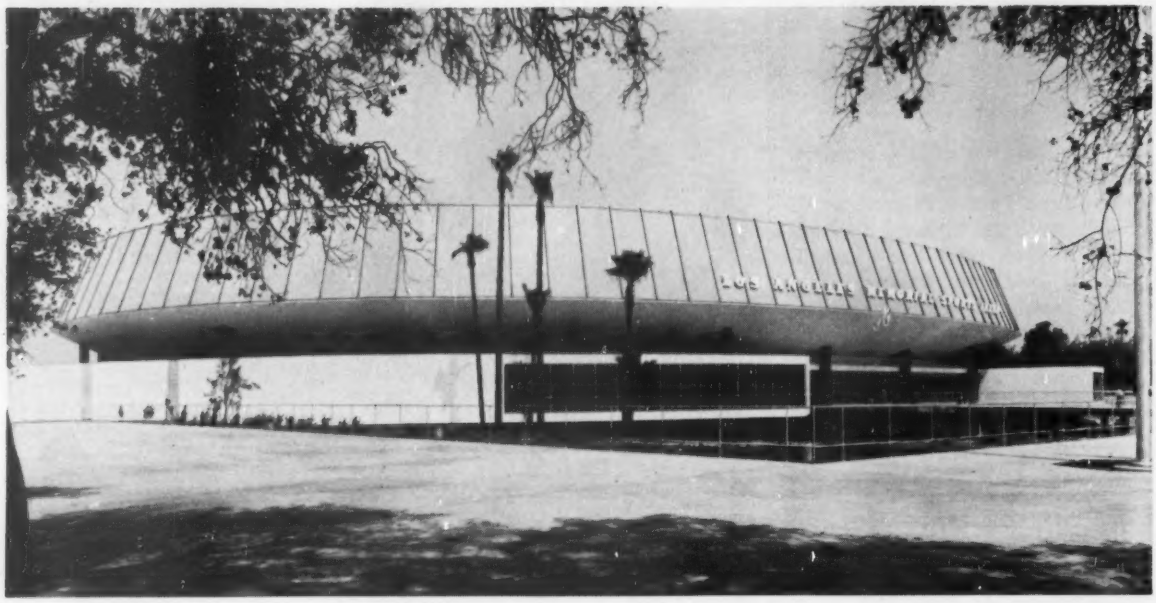
GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY INC.

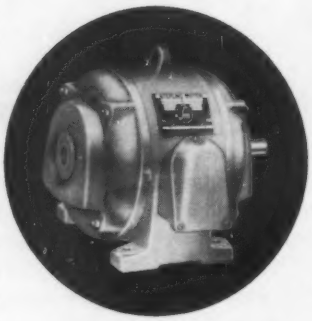
1551 LINCOLN AVENUE • HAMILTON, OHIO • TWinbrook 5-7491

Circle 521 on Page 19

FOR THE NATION'S MOST MODERN SPORTS ARENA... MODERN ELECTRIC MOTORS BY STERLING!



Equally suitable for sports events or convention meetings, the Los Angeles Memorial Sports Arena, site of the 1960 Democratic National Convention, is one of the nation's newest and largest public assembly buildings. Designed by Welton Becket and Associates, architects and engineers, for the Los Angeles Coliseum Commission, the Arena can accommodate up to 22,400 seats depending upon the type of event being held.



Because comfort is a vital factor in the use of the Sports Arena, every effort was made to insure that the air conditioning throughout the building would be unequalled in efficiency. Three basic air handling systems and two piping systems provide the necessary flexibility for the many variations in air conditioning loads that are required.

54 STERLING Electric Motors were selected to power the pumps, fans and air handling units. These alternating current, squirrel cage, drip-proof Sterling drives, ranging from 1 hp to 75 hp, provide quiet and dependable service... service that has made Sterling the name to remember for modern electric drives.

Only STERLING Multi-Shielded A.C. squirrel cage motors provide *all* these advantages:

- *Patented herringbone rotor* assures quiet operation.
- *Splash resistant enclosure* provides many times the protection required by NEMA standards... protects against dripping liquids and falling objects.
- *Sterling Multi-Shielded protection* also incorporates sealed leads and terminal box, double-shielded prelubricated ball bearings and labyrinth seal on output shaft... for long, trouble-free service life.
- *Direct through ventilation* results in cooler motor operation and prevents overheating.
- *Mechanical and electrical modifications* are available for virtually any special application.

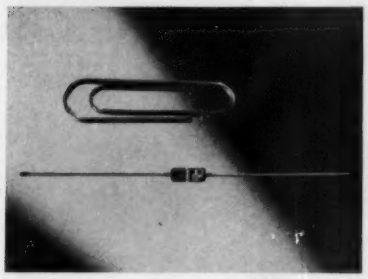
For additional information about the unmatched advantages of Sterling Multi-Shielded Motors for *your* application, write for free copy of Bulletin 194.

STERLING ELECTRIC MOTORS, Inc.

Offices and stocks in all principal cities. Over 400 distributors throughout the country to serve you.

KEEP PACE WITH ELECTRICITY

5401 TELEGRAPH ROAD • LOS ANGELES 22, CALIFORNIA



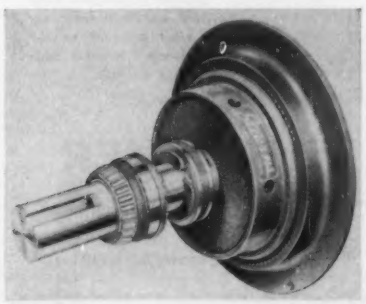
Unit also provides improvement in design safety margins for both switching time and reverse leakage. Reverse leakage at 100 C is 30 times lower than any computer type, and recovery time is 25 times faster than the best general-purpose type. Diode serves as an upgraded replacement for a large number of existing types. Diode is sealed in standard glass package and certified to MIL-S-19500B. **Rheem Semiconductor Corp.**, 350 Ellis St., Mountain View, Calif.

Circle 662 on Page 19

Multiple-Disc Clutches

have friction elements on OD of magnet body

Style F electromagnetic multiple-disc clutches are available in two, four, and six-disc friction surfaces with convenient adjustment features to compensate for lining wear. Friction elements are placed on the OD of the magnet body, making possible a longer torque arm for a given size unit. Friction area is also comparatively greater. Principal advantage of design is adaptability to mount in certain engine housings and power take-off units. Driven member or clutch cage is flanged for attachment to engine flywheels or other driven mechanisms. It is also adaptable to through-shaft drives with ball bearings or bronze-bushed mountings.



4 solutions to your special timing applications... HANSEN SYNCHRON TIMING MOTORS

• **Versatile Hansen SYNCHRON Timing Motors** have *proved* more dependable in meeting impartial test requirements than competing motors. Such tests prove that Hansen SYNCHRON motors deliver peak operating efficiency continuously for as much as 1½ years, and longer.

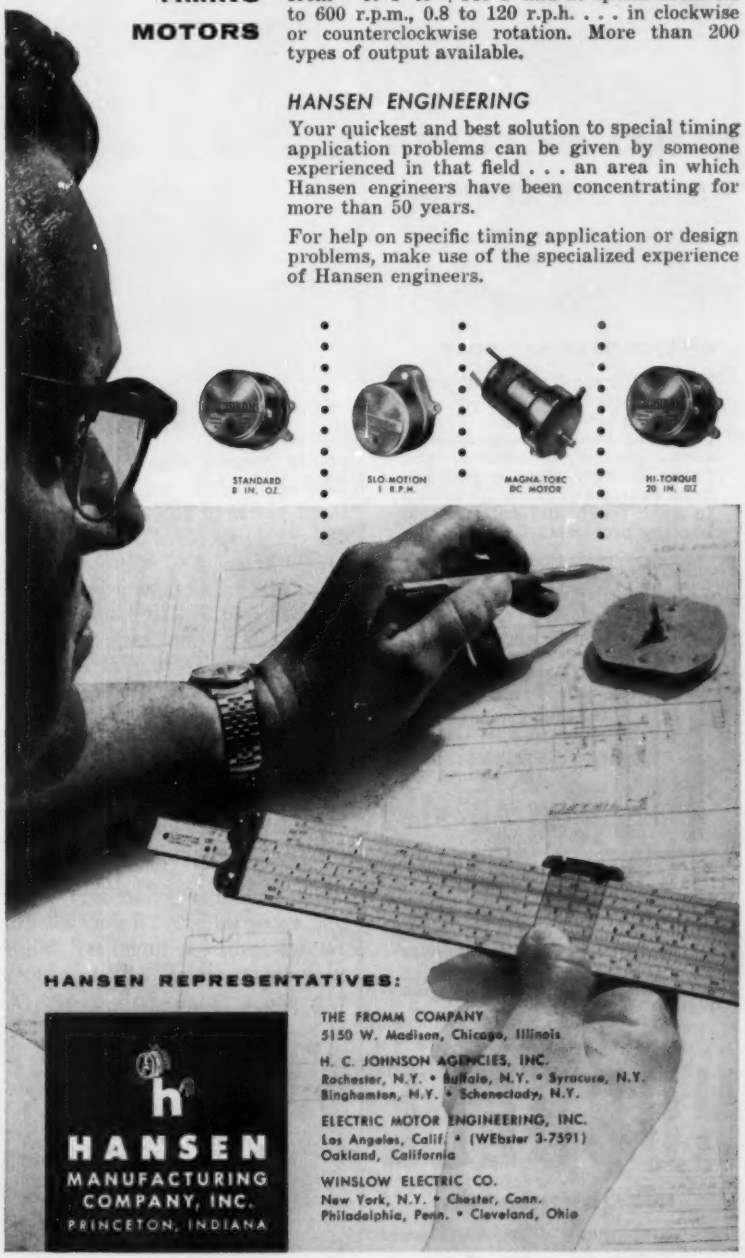
Each of the 4 Hansen SYNCHRON Timing Motors shown here gives this kind of performance . . . and one could be the solution to your timing problem. Some of the wide variety of commercial and industrial applications include: timing machines; telemetering and transmission equipment; cam and valve switches; heating and air conditioning devices; recording thermometers; television cameras and equipment; and many others.

Self-starting and self-lubricating, these Hansen SYNCHRON Timing Motors operate efficiently in any position. They pull from 8 to 30 in./oz. guaranteed torque . . . at temperatures ranging from —40°F to +140°F and at speeds from 0.8 to 600 r.p.m., 0.8 to 120 r.p.h. . . . in clockwise or counterclockwise rotation. More than 200 types of output available.

HANSEN ENGINEERING

Your quickest and best solution to special timing application problems can be given by someone experienced in that field . . . an area in which Hansen engineers have been concentrating for more than 50 years.

For help on specific timing application or design problems, make use of the specialized experience of Hansen engineers.



HANSEN REPRESENTATIVES:

THE FROMM COMPANY
5150 W. Madison, Chicago, Illinois

H. C. JOHNSON AGENCIES, INC.
Rochester, N.Y. • Buffalo, N.Y. • Syracuse, N.Y.
Binghamton, N.Y. • Schenectady, N.Y.

ELECTRIC MOTOR ENGINEERING, INC.
Los Angeles, Calif. • (WEbster 3-7591)
Oakland, California

WINSLOW ELECTRIC CO.
New York, N.Y. • Chester, Conn.
Philadelphia, Penn. • Cleveland, Ohio

HANSEN MANUFACTURING COMPANY, INC.
PRINCETON, INDIANA

Circle 523 on Page 19

*Savings like this deserve a closer look

COLD HEADING SAVES OVER 300%

ON THIS TERMINAL POST

Due to the many technical problems involved, only Hubbell was willing to tackle this job. The result: big savings in production costs, greater uniformity, and faster delivery. This is just one more example of Hubbell's ability to solve tough and unusual cold heading problems.

Original Screw Machined Part	Same Part Re-designed for Hubbell Cold Heading
	HEAD INDENTED to fill out sides, make corners sharp **MINIMUM FILLET** under head to permit close seating **SHANK EXTRUDED** due to equal dia. of shank and thread **CLOSE TOLERANCE MAINTAINED** on length and diameter **CRITICAL FIT . . .** to class #2 specifications

*A closer look at your fastener requirements may reveal some that lend themselves to the economies of Hubbell cold heading. If so, investigate! Send us samples or blueprints of the parts for analysis and estimate. No obligation.

HARVEY

HUBBELL

INCORPORATED

Machine Screw Department Bridgeport 2, Connecticut

Circle 524 on Page 19

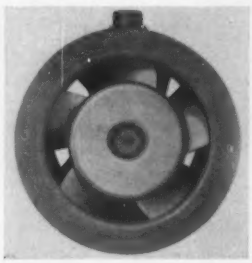
Proposed sizes are 7, 9, 13, and 15-in. diams with torque ratings to 4000 lb-ft. **Stearns Electric Corp.**, 120 N. Broadway, Milwaukee 2, Wis.

Circle 663 on Page 19

Vane-Axial Blower

for a variety of electronic cooling applications

MSA-11000 vane-axial blower unit meets environmental conditions of applicable military specifications, and has a nominal air-delivery rating of 350 cfm at a static pressure of 5.8 in. of water (standard density). Unit is available for a variety of electronic cooling applications with a wide range of



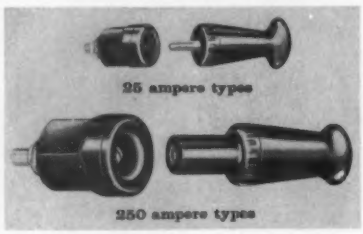
power sources and motor speeds. Blower models are available for input power of 115, 200, and 440 v, 400 cps, in speeds of 5400, 7500, and 11,500 rpm. DC motors can also be provided. Complete blower unit weighs about 5¾ lb and is 7 in. in diam and 6.2 in. long. **Specialty Blower Div., Torrington Mfg. Co.**, Torrington, Conn.

Circle 664 on Page 19

Electrical Connectors

for 25 or 250-amp use have fishtail plug design

Single-conductor Supercon plugs and receptacles in 25 and 250-amp ratings feature a functional fishtail plug design, simplified, quick assembly, and a range of six colors. All



"the HITCHINER way..."

allows **flexibility in design** with INVESTMENT CASTING

This part is a carrier for a stripper on a citrus peeling machine. It is typical of thousands of irregularly shaped components that are designed with only a particular function in mind and no compromise with production limitations. This type of metal part often requires several changes before the design is finalized.

A late design change in this part, cast in 303 stainless steel, incorporated a 45° bevel, top and bottom on both sides of the serrated pad section. The tooling was altered at very little cost while the cost of the finished casting was not increased at all. The relatively low cost of tooling and tooling changes make the investment casting process an economical and flexible method.

Flexibility in design, a wide freedom of choice in alloy and the elimination of expensive machining operations made possible with the investment casting process may help you solve your parts problems. Send us your sample or blueprint and find out with a Hitchiner "engineered quotation" — no obligation.

Find out how our new ceramic shell technique can possibly benefit you. Send for our free, new revised brochure on the latest investment casting methods.

HITCHINER
MANUFACTURING COMPANY INC.
MILFORD 21, NEW HAMPSHIRE

Coast to Coast Engineering Representatives

Circle 525 on Page 19

Variable Speed Simplicity Economy

REEVES vari-speed MOTOR PULLEY

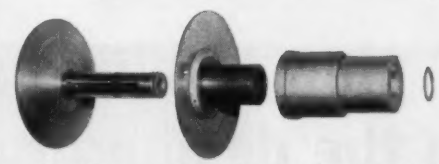
The obvious advantages you gain from this Reeves Motor Pulley design are accurate variable speed control, low cost operation, no problems.

It's as simple as this: There are two smooth-faced cone-shaped discs, one mounted in fixed position on the motor shaft, the other designed to slide laterally on the hub of the fixed disc. Belt tension spring automatically maintains pressure on the sliding disc for correct belt tension at all output speeds, while smooth, stepless speed changes are accomplished by adjusting the sliding motor base.

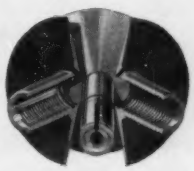
Disc Assemblies are available in nine sizes, ⅓ hp. through 15 hp. to fit either old or new NEMA motors. Speed ranges up to 4:1. Separately mounted countershaft assemblies are available to match any of your machine speed requirements. Your Reliance Sales Engineer has all the facts. Call him . . . or if you prefer, write for Bulletin No. GV-582-1.

G-1089

ONLY 3 MAIN PARTS!



Fixed Disc Sliding Disc Belt Tension Spring



ONE LUBRICATION POINT!

Reeves exclusive "Close Grooving" maintains a film of lubricant between hub length of fixed disc and bore of sliding disc . . . prevents sticking.

Product of the combined resources of Reliance Electric and Engineering Company and its Reeves and Master Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

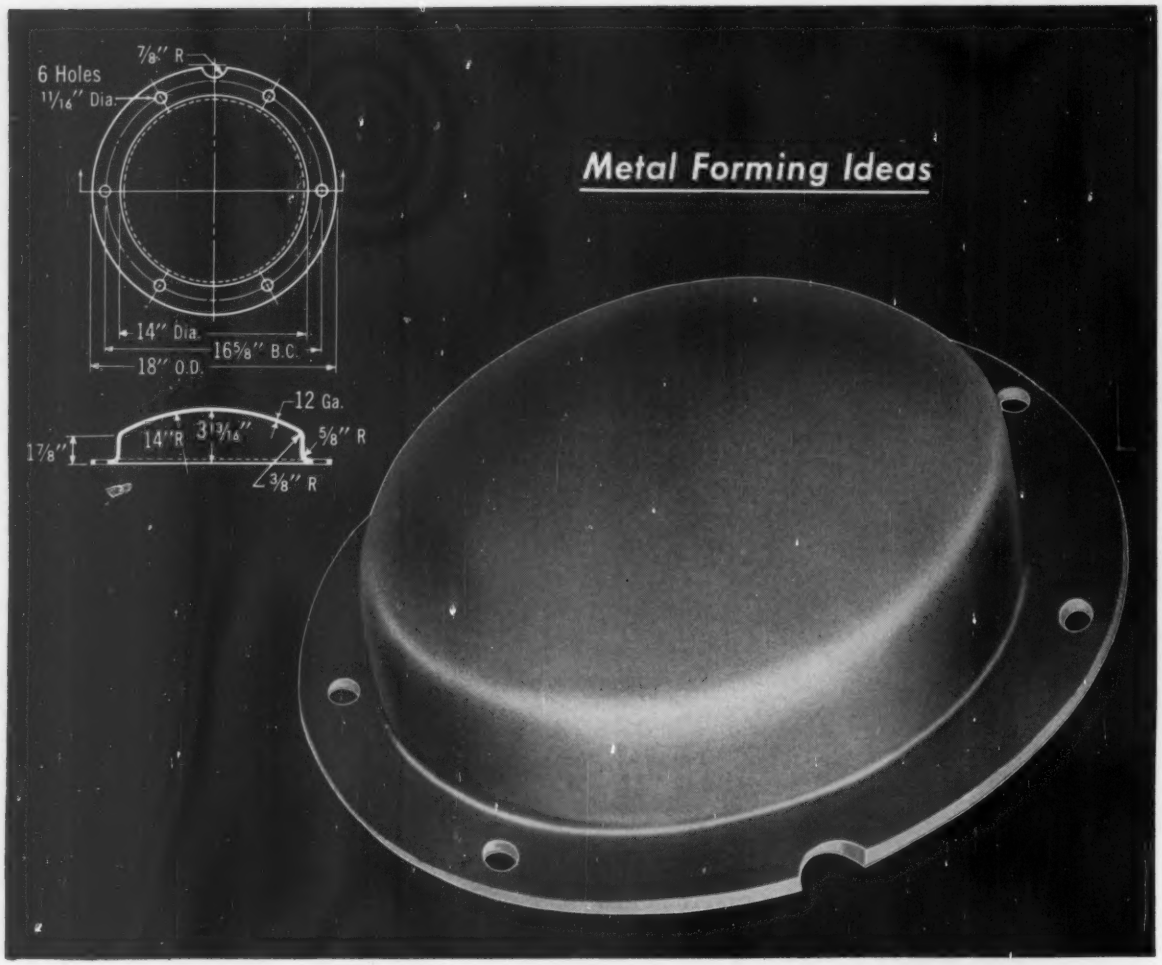
DEPT. 287A1, CLEVELAND 17, OHIO

Canadian Division: Toronto, Ontario

Sales Offices and Distributors in Principal Cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

Circle 526 on Page 19



How to eliminate special tooling in the design of custom-formed parts

Custom stampings, formerly prohibitive cost-wise, can now be inexpensively formed through the use of existing dies from COMMERCIAL'S "Die Bank" of almost 50,000 different forming die components.

A case in point: Wheel covers for American Coleman's aircraft towing tractor. They're important for the protection of the power transfer yokes in the tractor's four-wheel drive.

Stamping was first considered as the best method for forming them. The original low quantity involved and the amortization of $2,300 for special forming die costs, however, made the stamping unit costs impractical.

The covers were therefore first produced as machined, malleable iron castings at a cost of $8.49 per unit. A switch to hand spinning later reduced this cost to a still high $3.50 per cover.

American Coleman then discovered and investigated COMMERCIAL'S "Die Bank". From 24 basic shapes ranging 4" to 72" in diameter and involving metal thickness from 20 gauge to ¾" —all available through the use of existing dies adapted to presses up to 2000 ton capacity—emerged an entirely practical and economical solution to the unit cost problem.

The design: A standard, dished, offset shape with vertical and horizontal flanges and dish radius equal to its dished diameter. The wheel cover of 12 gauge, stamped steel now provides complete protection, necessary yoke clearance and a pleasing appearance.

Best of all, by using an existing forming die from COMMERCIAL'S "Die Bank", the actual tooling charge was only $80 for a simple modification of a single die component. And the unit cost was slashed to a practical $2.59.

The final result: A strong, lightweight wheel cover with a smooth surface for finishing which now completely and economically meets all requirements.

If your component requirement involves a custom-formed or unusual shape, and if the high cost of tooling prohibits its economical forming, the "Die Bank" service at COMMERCIAL may be just what you've been looking for. There's a quick way to find out. Just send along a blueprint, sketch or prototype of your part to Commercial Shearing & Stamping Company., Dept. S-30, Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping

Circle 527 on Page 19

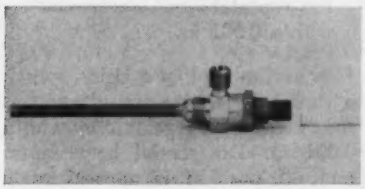
current-carrying parts are brass, gold-plated for stable electrical contact and resistance to corrosion. Plastic parts are durable nylon for high dielectric strength and excellent resistance to corrosive chemicals, oil, and grease, abrasion and impact, chipping and cracking. Cable connection to the plug can be made either by soldering or by fastening with two screws. Plug grips have simple, two-piece threaded construction for quick assembly and disassembly. Receptacles have color-matching caps and bodies to permit more rapid circuit identification front and back of panel. **Superior Electric Co.**, Dept. SPR, Bristol, Conn.

Circle 665 on Page 19

Miniature Air Valve

for temperatures from −350 to +1750 F

Miniature thermostatic air valve weighing 2 oz, primarily used as a power-limiting device when installed in the exhaust outlet of a gas-turbine engine, has been tested



successfully in cryogenic applications at −300 F. With 35 psi air applied at inlet, an output variation of 1 psi per 2 deg temperature change is obtainable through an adjustable range of −350 to +1750 **F. Solrac Inc.**, 11760 Vose St., North Hollywood, Calif.

Circle 666 on Page 19

Unloading Valve

has 5 to 20 per cent adjustable differential

Adjustable unloading valve automatically diverts full pump flow to a reservoir when system pressure reaches a preset point. Used in accumulator and high-low circuits, or for venting large relief valves, unit offers: A 5 to 20 per cent adjustable differential between load and unload pressures for better sys-

NEEDED: EFFECTIVE VIBRATION ISOLATION AT TEMPERATURE EXTREMES

Vibration-sensitive equipment in high performance missiles and aircraft often poses a two-pronged problem to design engineers: effective isolation against destructive shock and vibration—*at temperature extremes.*

ANSWER: MB'S NEW BROAD TEMPERATURE METAL ISO-DAMP (tm) MOUNT

MB's new broad temperature Iso-Damp mount consists of two load carrying springs, mounted in opposed position, with built-in damper assembly to restrict resonant build-up. It requires no external cooling, can be used at temperatures from −100°F. to +500°F.

WHAT'S YOUR MOUNT PROBLEM?

These new mounts can be adapted easily to the isolation of other special equipment as well. Or, perhaps one of MB's many other mount designs may be the answer to your particular vibration control problem. MB has not only the mounts, but also the experience and personnel to find the right answer for you. Write us for complete information—ask for Bulletin 418-4.

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC.
1056 State Street, New Haven 11, Conn.

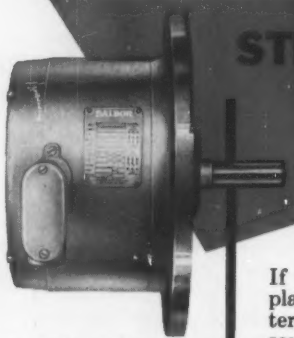
Circle 528 on Page 19

...to

meet the most exacting requirements of today's precision-built equipment!

BALDOR

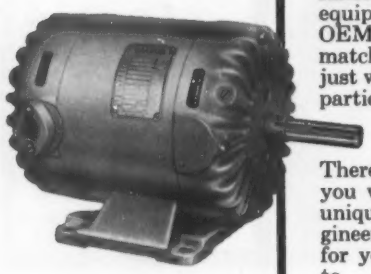
STREAMCOOLED MOTORS



COMPACT MOTOR—specially designed by Baldor for use where space is limited. Combines minimum length with minimum diameter.

If your equipment demands a power-plant with special performance characteristics, chances are BALDOR's "personalized" engineering service can be of valuable assistance.

For the past 40 years BALDOR has specialized in special motors—designing and building them to be a smooth-functioning and integrated part of the equipment they power. As a result OEM's are assured of motors perfectly matched to specific applications—not just warmed-over and changed to meet particular needs.



There's a BALDOR representative near you who will gladly explain how this unique and extremely competent engineering service can be put to work for you. See him soon or write direct to . . .

AIR-OVER MOTOR—built by Baldor for crop dryer use. Fractionals resiliently mounted for maximum quietness . . . integrals rigidly mounted for maximum ruggedness.

Our 40th Year!

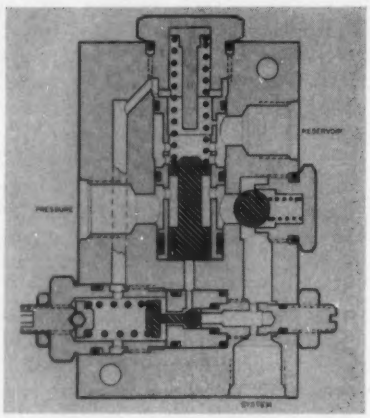
Baldor Electric Company

4353 Duncan Ave. • St. Louis 10, Mo.

Over 500 Authorized Sales & Service Distributors in U. S. A.

District Offices: Atlanta • Chicago • Cleveland • Dallas • Dayton Des Moines • Detroit • Litchfield, Conn. • Los Angeles • Milwaukee Minneapolis • New York • Kansas City, Mo. • Oakland • Philadelphia Portland, Ore. • Syracuse

AVAILABLE IN OLD AND RE-RATED NEMA FRAMES!



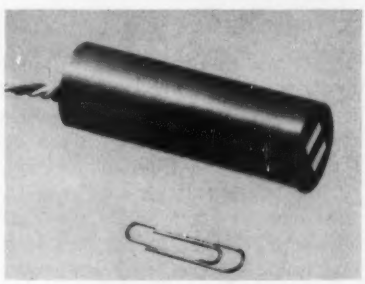
tem efficiency; and a sliding spool that will not stop half way, assuring complete loading and unloading. Valve also has a built-in check valve and an internal pilot that eliminates extra piping. Unload pressure range is 800 to 3000 psi, and maximum pilot pressure is 5000 psi. **Fluid Controls Inc.**, Box 186, Mentor, Ohio.

Circle 667 on Page 19

Proximity Switch

has repeatability within 0.001 in.

New cylindrical proximity switch with microsensitive transducer has snap action and repeatability within 0.001 in. Differential between on and off position is approximately 0.008 in. Coil-spring loaded, the shock-resistant switch maintains high constant pressure and cannot dwell between on and off position. Contacts are rated 6 amp at 110 v resistive and 3 amp at 220 v for nominal life. Switch is actuated by objects traveling either axially or tangentially. It is unaffected by random magnetic influences. Switch can be mounted integrally within or flush to the machine or device. Only 13/16 in. OD and 2½ in.



long, it is sealed against moisture, dust, and other contaminants. **Tann Controls Co. Div., Tann Corp.**, 3750 E. Outer Drive, Detroit 34, Mich.

Circle 668 on Page 19

Worm-Gear Reducers

are small fan-cooled units

Radicon small-size right-angle worm-gear reducers have center distances from 1⅛ to 8 in. Features include fan cooling to promote maximum thermal capacity and de-

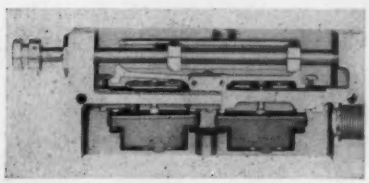
tachable feet to give unlimited mounting flexibility. Twelve sizes have input capacities from 0.01 to 68 hp and output torque up to 46,000 lb-in. Speed ratios range from 5:1 to 70:1. **Foote Bros. Gear & Machine Corp.**, Box MJ, 4545 S. Western Blvd., Chicago 9, Ill.

Circle 669 on Page 19

Linear Control Units

control strokes of air and hydraulic cylinders

Self-contained packaged units provide simplified control of the strokes of air and hydraulic cylinders and other linear machine movements. Cast-aluminum housing unit is ready to operate on the machine by one rigid mounting of the entire unit, one electrical lead, and a single attachment to the source of power. Single rod reciprocating with the source of power through a tube actuates switches within aluminum



POLYPENCO® MC NYLON

an economic breakthrough in nylon production

New processing techniques drop nylon tubular bar prices as much as 50%

ROD AND SLAB

Rod up to 17" in diameter, and slab from 1 to 5 inches thick in sections of 2 ft. x 3 ft. are available on special request. Other symmetrical shapes—produced with new economy—and in larger sizes than heretofore produced—are under development.

New design opportunities are open to manufacturers and users of large bronze and babbit bearings.

POLYPENCO MC Nylon 901, a specially formulated bearing compound, is available in tubular bars at prices below those of quality bronze bushings.

Polymer's new MC Nylon has improved wear characteristics and greater resistance to deformation under load . . . proven by field tests.

TUBULAR BAR STOCK SIZES

MC Nylon tubular bars, the first standard availability in MC Nylon, are made in outside diameters ranging from 2" to 15". Wall thicknesses of ⅜", ½", ¾" and 1" are standard with wall thicknesses up to 2" made to order. Standard lengths up to 13". Supplied in POLYPENCO blue.

Call or write today for full information.

The Polymer Corporation of Penna.
Reading, Pa.
Export: Polypenco, Inc., Reading, Penna., U.S.A.

POLYPENCO®

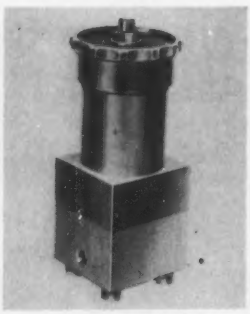
box. Control unit can be mounted alongside, ahead, behind, or remotely from source of power. Standard units feature two reciprocal switch-actuating means in ¼ to 18-in. strokes in medium and heavy-duty models. **Paramount Textile Machinery Co.**, 131 S. Wabash Ave., Chicago 3, Ill.

Circle 670 on Page 19

Pressure-Reducing Valve

for initial pressures of 4000 psi

Pressure-reducing and relief valve is for water, oil, air, and gas service to initial pressures of 4000 psi. Available in ⅛ and ¼-in. sizes, No. 3850 Type F valve controls small units under test or supplies a process or piece of equipment requiring small capacity. Adjustable pressure ranges are 0-1000, 0-2000, and 0-3500 psi. Pressures can be controlled within as little as 2-3 psi over entire adjustable pressure range. Single-seated, spring-loaded, diaphragm-actuated valve is simple



in design, containing neither external actuating connections nor stuffing boxes. Body is heat-treated aluminum bar stock with bronze and Monel trim. **Atlas Valve Co.**, 280 South St., Newark 5, N. J.

Circle 671 on Page 19

Synthetic Instrument Grease

has long life over wide temperature range

Anderol L-793 synthetic grease is for instrument applications over a temperature range of −75 to +300 F. A lithium soap grease, it has built-in rust protection, making it suitable as a long-life lubricant for clocks and watches, precision bearings, pneumatic and hydraulic systems, and all types of precision instruments. Completely compatible with ordinary lubricants, grease offers penetration comparable to fine penetrating oils. Nongumming and stable, it leaves no harmful deposits on precision parts. **Industrial Lubricants Div., Lehigh Chemical Co.**, Chestertown, Md.

Circle 672 on Page 19

Sealed Temperature Control

is vibration-proof snap-acting unit

Vibration-resistant sealed temperature control is designed for inboard and outboard motors, hydraulics, diesel engines, industrial air compressors, and motor generator sets. Used as a high limit or controlling thermostat, unit is identified as Type OM. Features include free actuating snap-action disc, rapid temperature response, permanent calibration, long life expectancy, and constant contact pressure. Control is SPST, normally open or closed. Electrical rating is 4 amp at 32 v,

Mr. W. C. Guenst, Jr. of Master Etching Company, Wyncote, Pa. says:

"General Electric's Polydyne® Drive Adds Three Important Sales Features To Our Product" **Accurate speed control, wide speed range and fast speed-changing capabilities mean time savings and better printing plates for users of Master Etching Machine Company's powderless etcher.**

These features, along with compact size, low maintenance and operating simplicity, have made Polydyne drives the EXCLUSIVE choice of Master Etching Company for the mechanical adjustable speed drive on their model M-32 etcher.

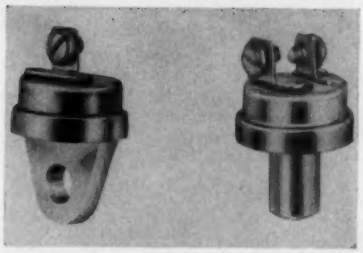
With Polydyne drives you can get a wide range of process speeds and adapt machine speed to meet requirements of different operations with fewer machines—*straight from a-c power.*

Why not investigate the advantages of using a Polydyne drive on *your* equipment? Polydyne drives are available from ¼ to 25 hp with output speeds from 4200 to 5 rpm in a wide variety of configurations and enclosures.

For more information, contact your G-E Apparatus Sales Office or Distributor, or write for Bulletin GEA-6806, Section 854-04, General Electric Co., Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC



case grounded. Vibration is 5 cps at 0.1 in. displacement through 2000 cps at 20 g. Ambient temperature exposure is −65 to +325 F, and minimum nominal differential is 20 F. Temperature setting range is −40 to +300 F. **Thermo-O-Stats Inc.**, P. O. Box 303, Chartley, Mass.

Circle 673 on Page 19

Insulating Material

has excellent moisture resistance

Anilite insulating material combines good electrical properties and mechanical strength of vulcanized fiber with low moisture absorption of phenolic laminates. It incorporates synthetic resins which provide two to four times the moisture resistance of conventional vulcanized fiber. Material affords good dimensional stability and retention of insulating properties in a variety of atmospheric conditions. It is flame resistant, has superior arc resistance, can be drawn or formed into permanent shapes, and can be punched and machined at low cost. Anilite is available in sheets 0.004 to 0.125-in. thick and 48 in. wide by 72 in. long. **National Vulcanized Fibre Co.**, 1060 Beech St., Wilmington 99, Del.

Circle 674 on Page 19

Epoxy Laminate

for extreme physical and electrical applications

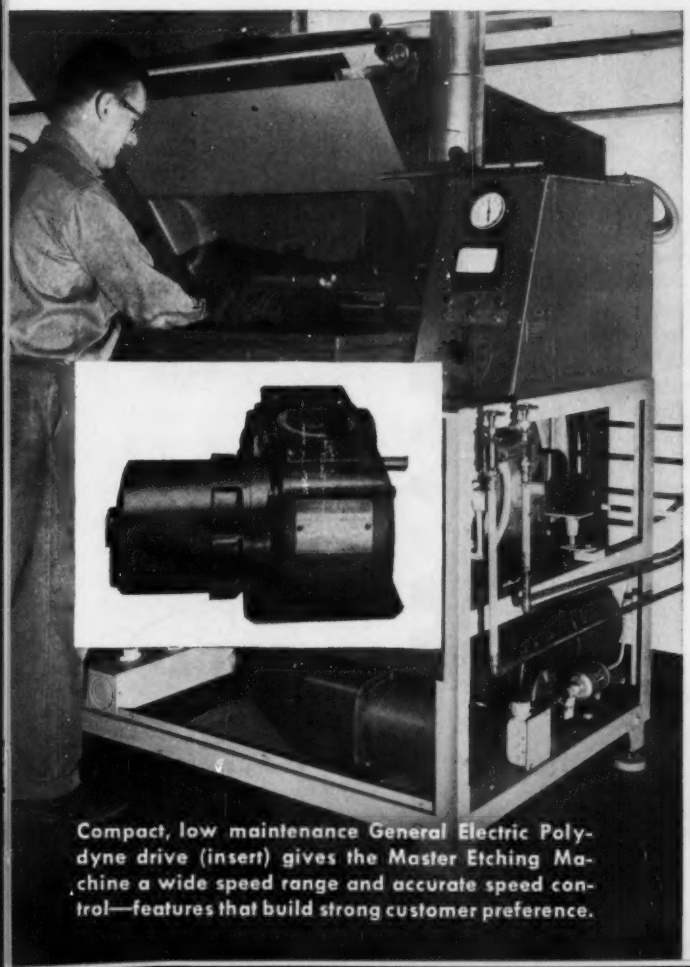
Spauldite G11-820, a glass-base epoxy laminate, maintains over 50 per cent of its flexural strength at 150 C without loss of high electrical and mechanical properties. Material is for extreme physical and electrical applications, such as in computer, missile, and aircraft components. Material is available in 40 x 48-in. sheets, copper-clad or unclad strips, blocks, or in fabricated parts to precise customer specifications. Thicknesses range from 1/32 to ½ in. Material is flame retardant and self-extinguishing by ASTM-D635. **Spaulding Fibre Co. Inc.**, 310 Wheeler St., Tonawanda, N. Y.

Circle 675 on Page 19

Servo Motor

size 8 unit is only 0.840 in. long

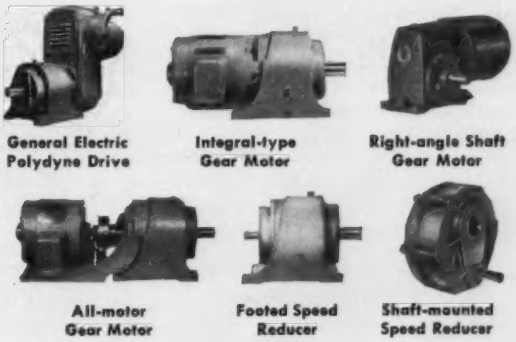
New Size 8 servo motor, No. 8SM-461, is wound for 115-v sources, yet is only 0.840 in. long and weighs 1.1 oz. Unit provides high torque and low rotor-inertia required for precise, rapid response to minimum



Compact, low maintenance General Electric Polydyne drive (insert) gives the Master Etching Machine a wide speed range and accurate speed control—features that build strong customer preference.

General Electric Offers a *Complete* Line of Low-speed Drives 1/8 to 200 HP

Select from G.E.'s PLUS LINE of compact mechanical power transmission equipment! A full range of ratings is available—many directly from stock.



General Electric Polydyne Drive · Integral-type Gear Motor · Right-angle Shaft Gear Motor

All-motor Gear Motor · Footed Speed Reducer · Shaft-mounted Speed Reducer

General Electric would like to help solve your specialty mechanical power transmission problems.

For further information write:
Mr. C. R. Andersen, Mgr. Product Planning, Gear Motor & Transmission Components Department, 845 E. 25th Street, General Electric Co., Paterson, N. J.

Member of American Gear Manufacturers' Association

GENERAL ELECTRIC

Circle 531 on Page 19

(Advertisement)

No. 15 of a series

Eastman 910 Adhesive solves another production bottleneck

Hubley Manufacturing Company, of Lancaster, Pa., makes the Ric-O-Shay Pistol, a toy gun that simulates the whine of a ricochetting bullet.

The sound is generated by a bent musical wire vibrating against a thin brass percussion plate.

An L-shaped zinc alloy slug, die-cast onto the end of the wire, must be properly positioned and rigidly mounted in the percussion plate rim to obtain a realistic sound. Several fastening techniques were tried, with limited success. The high-strength bond and simple application of quick-setting Eastman 910 Adhesive solved the bottleneck.

Use of this adhesive produced a bond with the high resistance to vibration necessary for long service life.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9107 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. M-7, Kingsport, Tenn. (Not for drug use)
See Sweet's 1960 Prod. Des. File, 7/E

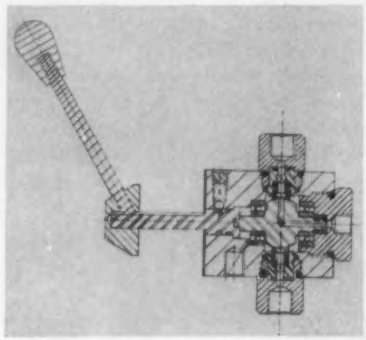
Circle 532 on Page 19

control signals. Model has a rotor inertia of 0.18 gm-cm² coupled with a stall torque of 0.22 oz-in., providing acceleration at stall of 86,500 rad per sec per sec, three times greater than any equivalent unit. Liberal use of stainless steel, and choice of Teflon as the standard insulating material throughout, enables the unit to withstand an ambient temperature range of −55 to +130 C. Maximum unit operating temperature is 200 C. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif.

Circle 676 on Page 19

Selector Valve

has spherical rotor design



Six-position, manually operated, multiple-selector valve for hydraulic circuits features a spherical rotor design which permits the selection of flow from any one of six sources, or directs one flow to any one of six circuits. Weight of the unit is only 1 lb 8 oz. Built for 0 to 6000 psi operating pressure and 10,000 psi proof pressure, valve has a rated flow capacity of 0.5 gpm. It is used in machine-tool, test-stand, and other small high-pressure circuits where positive sealing and low turning torque are required. Standard valves are available with ⅛-in. NPTF and ¼-in. SAE ports. **Sarasota Precision Products Inc.**, 5757 McIntosh Rd., Sarasota, Fla.

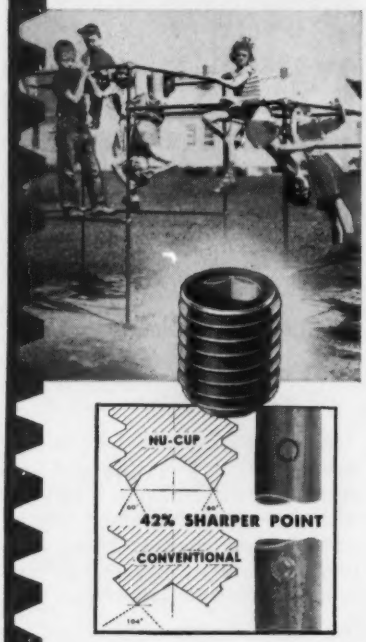
Circle 677 on Page 19

Electric Heating Elements

withstand operation at temperatures over 450 F

Electric heating elements or power resistors incorporate three new de-

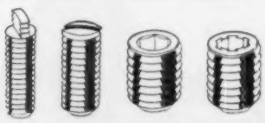
they're safe
with SETKO
NU-CUP*
set screws on the job!



Whether it's supporting children on monkey bars or harnessing a spinning shaft you'll find NU-CUP set screws dig in deeper and hold tighter. The shaft illustrated here tells the story.

NU-CUP has a 42% sharper point which penetrates in a deep, full circle giving tremendous holding power. In some cases it actually reduces the number of set screws needed for the job.

You can get them in slabbed, slotted, hex or fluted socket.



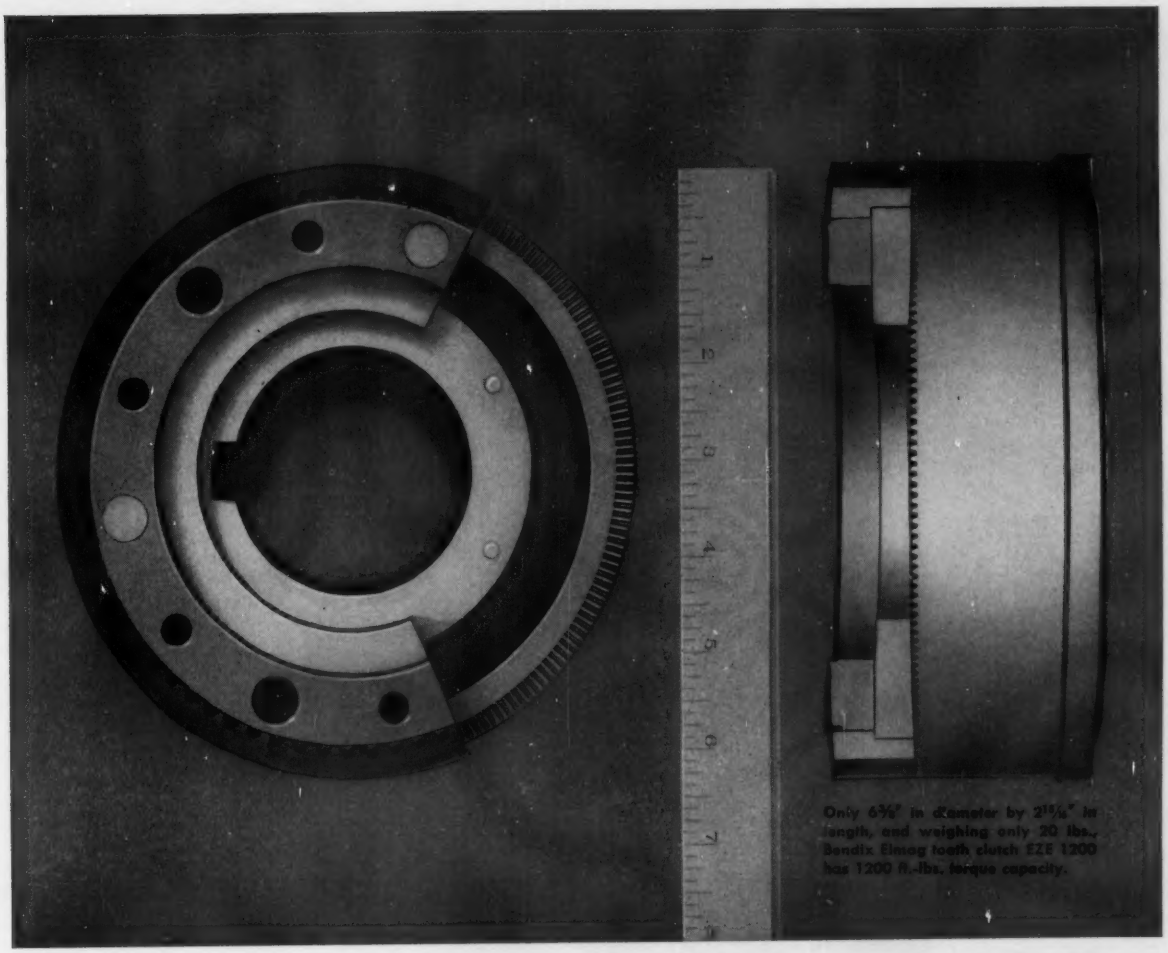
SEND FOR FREE TEST SAMPLES and full information. Ask about NU-CUP set screws. Catalog 23 free on request.

*U.S. Pat. No. 2,778,265

SETKO
Set Screw & Mfg. Co.
28 Main Street, Bartlett, Illinois

875

Circle 533 on Page 19


Only 6¾" in diameter by 2¹⁵⁄₁₆" in length, and weighing only 20 lbs., Bendix Elmag tooth clutch EZE 1200 has 1200 ft.-lbs. torque capacity.

Designed for more torque in less space

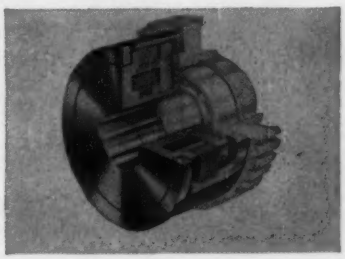
BENDIX ELMAG* *(Electromagnetic)* TOOTH CLUTCH

Machine designers now can provide for greater machine capacity, or space savings—or both—with the Bendix Elmag tooth clutch. This small, efficient package offers greater torque transmittal than is provided by other clutches of the same size.

It is more positive and simpler in design (only 3 parts) than other kinds of clutches. There is absolutely no idle torque—no connection between driving and driven members once disengaged. The Elmag can be disengaged under full load at any RPM, and engagement at relative speed is possible. The clutch's simple, bolt-on design makes it easy to mount; there are no additional splines or springs, no external disengagement mechanism.

*TRADEMARK

Elmag tooth clutches are designed to perform in either wet or dry applications. They are available from stock in torque capacities ranging from 40 to 4,000 ft.-lbs.



BENDIX ELMAG MULTIPLE DISC CLUTCH—Ideal for step-by-step acceleration of large masses. Disc stack is magnetically isolated. Wet or dry operation. Slip ring or stationary field design. Torque capacities: 10 to 16,000 ft.-lbs.

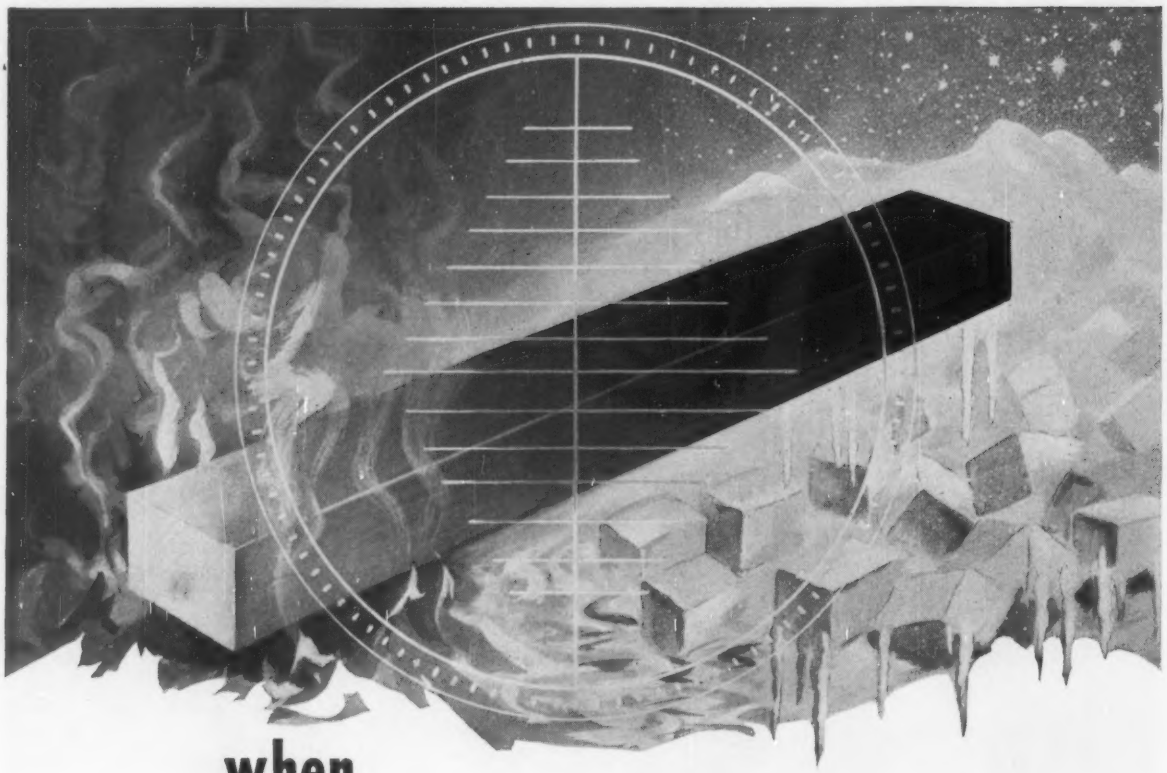
For full details, write

Bendix-Elmira
Eclipse Machine Division
Elmira, New York

THE Bendix CORPORATION

Circle 534 on Page 19

V-R METALS...



when dimensional stability is needed!

Does the size of a metal part have to change as its temperature does . . . and if so how much?

The change in size under various conditions can be a very critical factor. A part that must function accurately at sea level might be required to maintain that accuracy on a flight to the moon when the ambient temperature is —240° F. Under these conditions a new metal may be indicated.

Producing metals with low coefficients of expansion under extreme temperatures for dimensional stability and control is part of V-R's everyday activities. If you need a part with this characteristic or possibly one that is highly corrosion resistant . . . or one that has long wearing qualities . . . or one that has to take an extremely fine surface finish . . . then contact V-R.

V-R VASCOLOY-RAMET

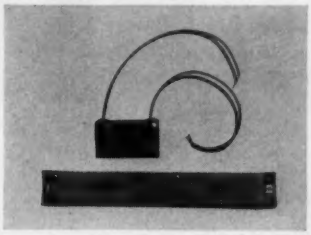
CREATING THE METALS THAT SHAPE THE FUTURE

A-781

850 MARKET STREET • WAUKEGAN, ILLINOIS

Circle 535 on Page 19

velopments which combine to provide for low cost. Automatic element winding machines provide high quality at low cost. New means of pressure connection of leads or lugs to resistance wire reduces manufacturing labor. New 450-F primer and cement are now



available. No pressure is required and cement sets up at room temperature. Insulation used is silicone rubber and glass-fiber cloth. Assembly withstands continuous operation at temperatures in excess of 450 F. Units are furnished in 1-in. widths and over-all lengths of 1½ to 12 in. Thickness is 0.12 in. or less. Resistance per unit of length can be from 1.27 to 1800 ohms per inch of heated length. **Electro-Flex Heat Inc.**, 83 Woodbine St., Hartford 6, Conn.

Circle 678 on Page 19

Silicon Rectifiers

occupy ½ the space of equivalent tube circuitry

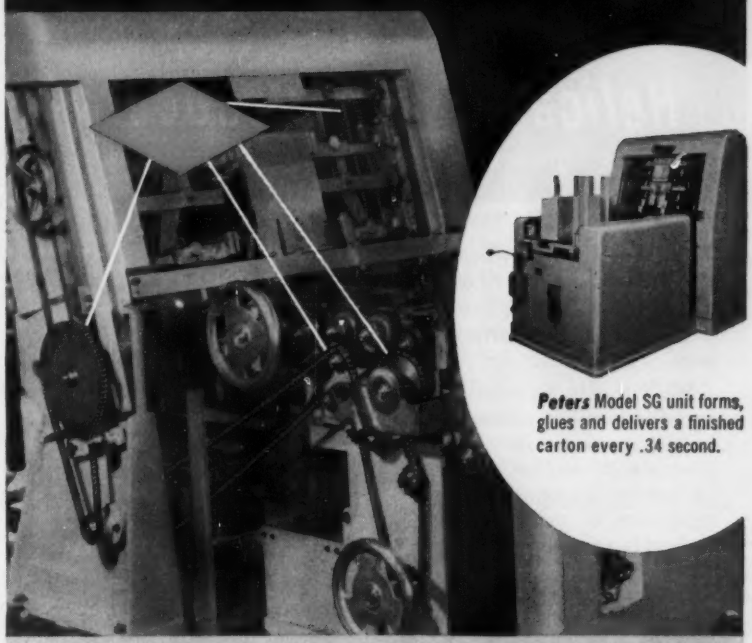
High-voltage plug-in silicon rectifiers directly replace Types 8008 and 872A mercury-vapor rectifier tubes. By eliminating the filament transformer and time-delay relay necessary to tube operation, they occupy one-half the space and weigh less than one-half of equivalent tube circuitry. Rated at 10,000 v peak inverse voltage and 1250 ma dc output at 75 C, the ST-9 and ST-10 are equipped with tube bases to

Peters Packaging Machine

synchronized by

DIAMOND Roller Chain

delivers 175 cartons a minute



Peters Model SG unit forms, glues and delivers a finished carton every .34 second.

A small error in split-second timing could cause a monumental snarl of cartons, glue and machine parts. To insure *precise synchronization* and dependable, trouble-free performance, Peters Machinery Company, Chicago, Illinois, specifies DIAMOND Roller Chain for high-speed packaging equipment.

The proven strength, durability and high dimensional accuracy of DIAMOND Roller Chain offer many opportunities to improve and simplify machine design . . . to solve conveying, timing and power transmission problems.

Write for catalog containing complete information on DIAMOND Roller Chain and Sprockets. Engineering assistance is available.

DIAMOND CHAIN COMPANY, INC.

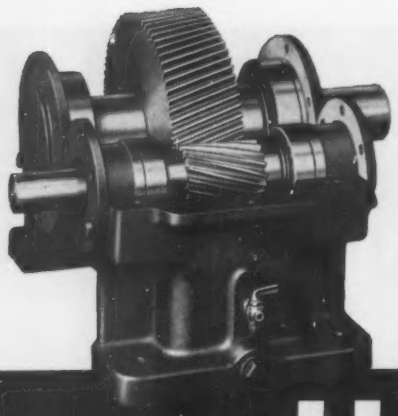
A Subsidiary of American Steel Foundries

Dept. 435 • 402 Kentucky Ave., Indianapolis 7, Indiana

Offices and Distributors in all Principal Cities

DIAMOND ROLLER CHAINS ®

Circle 536 on Page 19



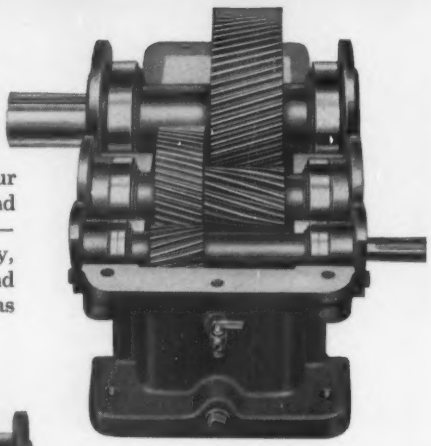
Fast Delivery on Custom Requirements

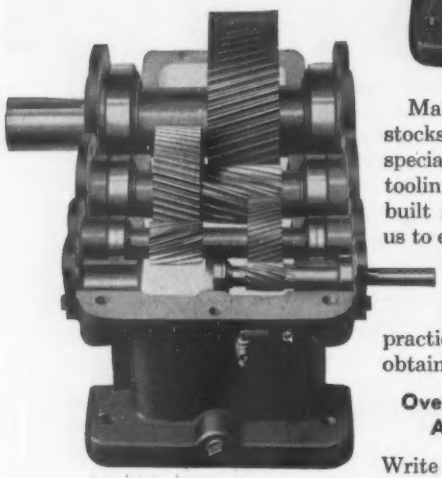
Specify H & S Helical Speed Reducers

Single · Double · Triple Reduction

You get *fast action* when you come to Horsburgh & Scott with your speed reducer and gearing problems.

We are able to meet your specifications—or design and build to your specific needs—products of highest quality, backed by the experience and reputation of many years as leaders in the gearing field.





Maintaining one of the largest stocks of patterns and blanks . . . special equipment and special tooling—much of it designed and built in our own plant—enables us to engineer and produce a wide range of custom gearing and transmission requirements, economically and practically as fast as you can obtain them from stock sources.

Overall design conforms to AGMA specifications

Write for details on wide size and capacity range of H&S Speed Reducers—Helical, Herringbone, Worm Gear and combinations.

H&S The HORSBURGH & SCOTT CO.

5112 Hamilton Avenue • Cleveland 14, Ohio

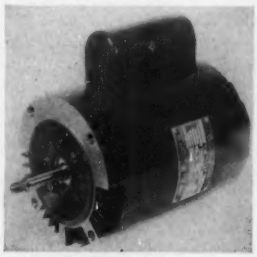
Specializing in fast production of quality Speed Reducers and Gearing to meet custom requirements.

allow direct insertion into existing tube sockets. They have an operating temperature range from −65 to +75 C, and provide the superior advantages of silicon-rectifier operation on a wide range of broadcast, television, short-wave transmitter, radar, airline, industrial RF induction heating, and other power communication and industrial applications. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 679 on Page 19

Water-Pump Motor

matches all jet-pump designs



Jet Line water pump motor in both 48 and 56-frame sizes is designed to match all existing jet-pump designs. The 48-frame motors are available in ratings of 1/3 hp, 60 cycle, single phase or capacitor start, and ½ hp, 60 cycle, capacitor start. The 56-frame motors are in ratings of ¾, 1, 1½, and 2 hp with three-phase, capacitor start. Speed at rated load is in excess of 3500 rpm. Electrical assemblies and mechanical parts of the motor are designed as individual units, physically independent of each other. Permanently lubricated bearings are designed so that the motor can be operated either horizontally or vertically without grease leakage. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

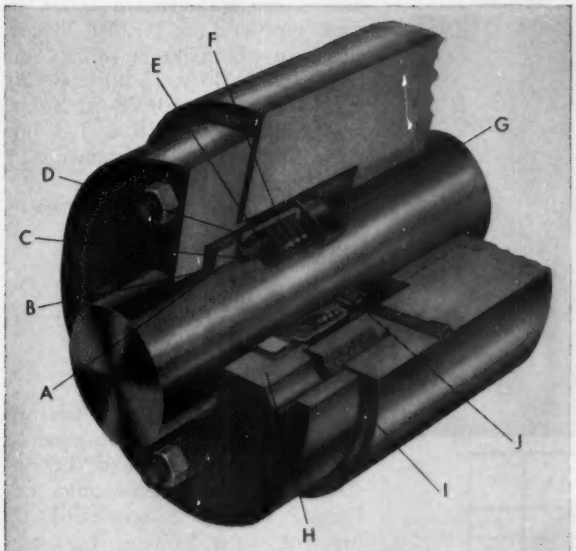
Circle 680 on Page 19

Motor Starters

are compact size-00 units

Dimensionally small in size, Size 00 is a magnetic, nonreversing motor starter which will satisfy approximately 40 per cent of all general-purpose applications up to 2 hp

MECHANICAL SEALS in Design Engineering



Garlock PK MECHANIPAK* Seal

A Stationary Seat—lapped face
B Vibration Ring
C Seal Ring—lapped face
D Case or Shell
E Bellows
F Spring
G Washer
H Gland
I Gasket
J Stop Collar

Where leak-proof operation is an absolute must, Garlock PK MECHANIPAK Seals are the ideal solution.

Easy to install and maintain. The Garlock PK MECHANIPAK is self-contained—no parts to "put together." Rotating portion simply slides onto shaft; stationary portion positions quickly into counterbore of gland. Once the Garlock PK MECHANIPAK is installed, further adjustment is unnecessary. No parts of the seal move on the shaft or sleeve, eliminating wear on shaft . . . spring in seal maintains contact between sealing faces.

For rotating shafts of equipment such as centrifugal pumps, automatic washing machines, commercial dishwashers, gear boxes, and speed reducers, Garlock PK MECHANIPAK Seals offer these operating characteristics:

PRESSURES—up to 150 p.s.i. with Buna-N or Viton† bellows

TEMPERATURES—up to 212°F with Buna-N bellows; above 212°F with fluid at faces and Viton bellows

SHAFT SPEEDS—up to 2000 f.p.m.; higher speeds possible depending on other operating conditions

LIQUIDS—water, oils, alcohol, mild acids and solvents

SIZES—for shafts 3/8" to 3" diameter

DRIVE—mechanical; install against shaft shoulder, sleeve, pump impeller, snap ring, stop collar or similar device.

To meet various operating conditions, PK MECHANIPAK seals are made in several different designs. For the complete story, get in touch with the Garlock representative in your area. Call him at the nearest of the 26 sales offices of Garlock throughout the U.S. and Canada. Or write for Catalog AD-150. Garlock Inc., Palmyra, N. Y.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Co.

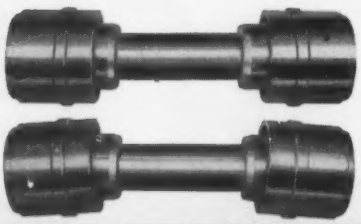
Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

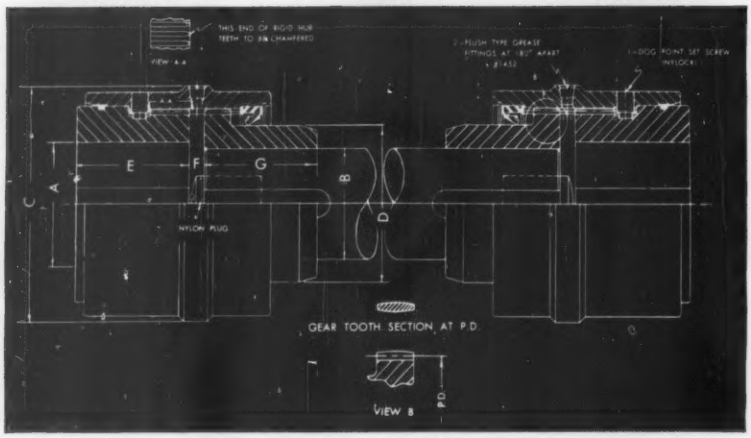
*Registered Trademark
†Du Pont Trademark

Circle 538 on Page 19

design facts....on

WALDRON
High
Misalignment
Series "X"





COUPLING SIZE	H.P. PER 100 R.P.M.	MAX. BORE RIGID HUB A	MAX. BORE GEAR HUB B	C	D	E	F	G
1¼X	3½	1⅜	1¼	3¾	2	2⅛	¼	2
2X	12	2⅛	2	4 17/32	2⅞	2⅜	5/16	2¼
2½X	26	2¾	2½	5 5/16	3⅝	2¾	⅜	2¾
3X	50	3⅜	3	6 11/32	4¼	3¼	7/16	3¼
3½X	86	4	3½	7⅜	5	3¾	7/16	3¾
4X	130	4½	4	8 3/32	5¾	4¼	½	4¼
4½X	210	5¼	4½	9 7/16	6½	4¾	½	4¾

The Series X coupling is specifically designed for transmission of power in applications where shaft misalignment is too great to be handled by a standard gear coupling.

Each coupling assembly has two rigid hubs, mounted on drive shaft and driven shaft, each connected to a one piece sleeve by a spline used for driving purposes only. This spline extends only a portion of the hub length, and the remaining length of the hub is a turned surface which fits snugly into the counterbore in the sleeve to provide a suitable bearing surface. These two sleeves are connected by a floating shaft on both ends of which are mounted flexible hubs with gear teeth of unique design which permits misalignment up to 5°.

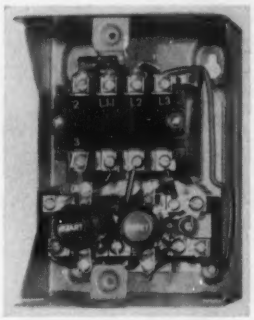
Series X couplings are easy to dismantle and reassemble. By backing off the set screws, the sleeves can be disengaged from the rigid and flexible hubs. Specially designed seals and steel protecting rings are held in place in the sleeves with Spirolox rings. End portions of the gear hubs are tapered for easy reentry of the seal in reassembly.

All load carrying parts are machined from high strength alloy steel. Floating shafts to customer specifications have nylon plugs inserted in each end to limit axial float and to prevent damage to the lathe centers of the roll shafts.

Write for Catalog

WALDRON Couplings

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
BOX 791, NEW BRUNSWICK, N. J.
SALES REPRESENTATIVES FROM COAST TO COAST



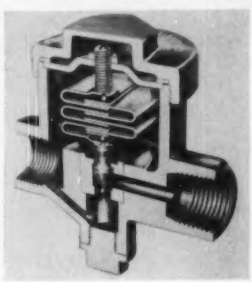
more economically than larger starters. Designed for use with both polyphase and single-phase motors, starter is available either as open type or in a NEMA Type-1 enclosure. Horsepower ratings are three phase, 110 v, ¾ hp; 208/220 v, 1½ hp; 380/440/550 v, 2 hp; and single phase, 115 v, 1/3 hp; 230 v, 1 hp. **Cutler-Hammer**, 315 N. 12th St., Milwaukee, Wis.

Circle 681 on Page 19

Steam Traps

are unaffected by pressure, water hammer

Low-cost, thermostatic steam-trap line includes high and low-pressure types in pressure-balanced thermostatic and float-thermostatic designs. Traps are unaffected by pressure, water hammer, frost corrosion, or rough handling. Operation is maintained by a rugged, stainless-steel, bimetal thermal element with universal joints. Maximum resistance to corrosion and metal fatigue is accomplished by use of forged aluminum-bronze for the bodies and stainless steel for all working parts. Applications include superheat service to 500 F. Line includes a variety of body styles, connections, and strainers. Pressure ranges for thermostatic units are vacuum to 25 psi, vacuum to 65 psi, vacuum to 125 psi, 0 to 225 psi,



Expert Night Pilot. In certain smaller types of bats, their amazingly precise echolocation enables perfect navigation and hunting of insects. Although the natural sonar system of bats is the smallest known, ounce for ounce and watt for watt it is billions of times more efficient than any sonar equipment that has ever been made by man.

Tiny Control Center. Synchronous at 24,000 r.p.m. in less than five seconds — using overvoltage techniques — this 2 oz., subminiature floated rate gyro assures stable, precise flight control of missiles, special weapons and space vehicles. MPB bearings on critical main shaft help assure accuracy under 150 G's of shock and 30 G's vibration to 2000 cps on any axis.

Man With Miracles. Friction, inertia, and today's ever-shrinking component space provide an exciting challenge to MPB Sales Engineer, Gene Burrichter. Working closely with engineers and scientists he constantly helps solve miniaturization problems throughout industry. MPB Sales Engineers are ready to give you similar assistance.

Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN SUBMINIATURE GYRO SHOWN ABOVE

In modern miniaturization many components have become so small they can hardly be seen. Yet they keep on doing as much work — or more — and getting closer to their designers' objectives. To engineers with new projects in this rapidly widening field, MPB's unequalled research facilities offer opportunities for highly effective teamwork. For details, and for a catalog on MPB bearings, the world's largest line, write to **Miniature Precision Bearings, Inc.**, 107 Precision Park, Keene, N. H.

MPB *Helps you perform miracles in miniaturization*

Circle 540 on Page 19

Which of these custom molding services can you use from STOKES

CUSTOM MOLDING TO
ELIMINATE ASSEMBLY OR REDESIGN INTO ONE-PIECE UNITS IN HARD RUBBER OR PLASTICS

For castings and other parts which are later machined and assembled, we frequently can suggest molded combinations which can eliminate most or all of the finishing and fitting work in a material which will meet your most rigid specifications.

When requesting further information, please indicate your major problem area other than assembly:

Area #1 Chemical resistance
Area #2 Close tolerances
Area #3 High temperatures
Area #4 High strengths
Area #5 . . . Other

CUSTOM MOLDING OF
SMALL RUNS 100 TO 1,000 PIECES IN HARD RUBBER OR PLASTICS

For complicated assemblies of weights up to 50 lbs (in rubber compounds) or up to 8 lbs (in plastics), many times we are able to suggest different mold designs which result in a one-piece part which needs little or no machining and drastically reduce previously required assembly time.

Our prices are competitive for plastic molding of parts up to 200 projected square inches and for molding rubber pieces up to 400 projected square inches.

Case histories are available for your consideration. Please specify resistance and stress requirements. No obligation for quotation and analysis.

STOKES MOLDED PRODUCTS

STOKES MOLDED PRODUCTS
1023 WEBSTER STREET
TRENTON 4, NEW JERSEY

☐ Please send us case histories regarding Area #.....
☐ Phone us to discuss our problems.
☐ We are sending blueprints and specifications for a quotation and analysis without charge.

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CITY ZONE STATE
PHONE

STOKES MOLDED PRODUCTS
1022 WEBSTER STREET
TRENTON 4, NEW JERSEY

☐ Send us case histories.
☐ Phone us to discuss our requirements.
☐ We are sending blueprints and requirements for a quotation and analysis without obligation.

NAME
FIRM
ADDRESS
CITY ZONE STATE
PHONE

STOKES MOLDED PRODUCTS

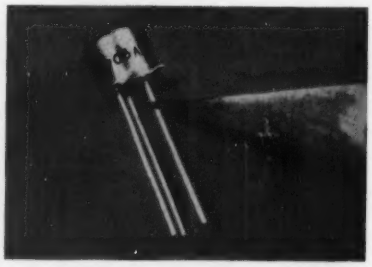
Circle 541 on Page 19 ↑ Circle 542 on Page 19 ↑

0 to 300 psi. Pressure ranges for float-thermostatic types are 0 to 75 psi and 0 to 150 psi. **MIL Div., Farris Engineering Corp.**, 702 Commercial Ave., Palisades Park, N. J.

Circle 682 on Page 19

Silicon Mesa Switch

for saturated circuitry



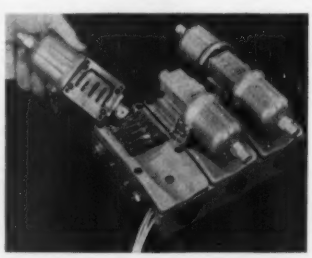
Silicon Mesa switch, No. 2N706A, is an ultra-speed unit designed for saturated circuitry where speed, reliability, and performance are a necessity. Expected applications are in aircraft and missile circuits, industrial, guidance, and control computer circuitry. Specific uses include such circuits as computer logic, flip-flops, binary counters, trigger generators, and electronic switches. **Semiconductor-Components Div., Texas Instruments Inc.**, P. O. Box 312, Dallas 21, Tex.

Circle 683 on Page 19

Air Valves

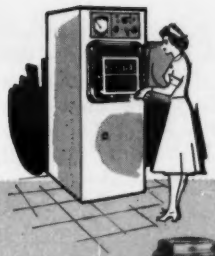
permit ganging in single manifold

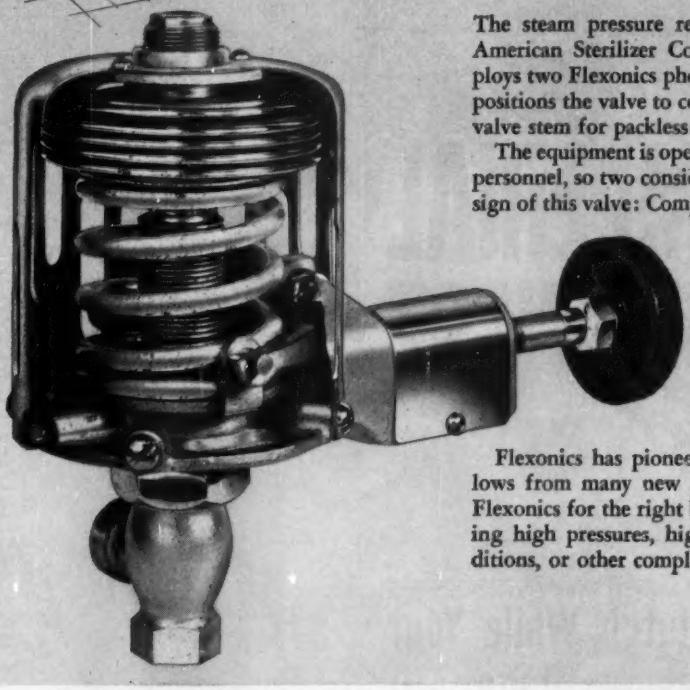
Solenoid-operated air valves can be combined quickly and easily to provide a single, compact, inexpensive manifold to suit exact requirements of any application. Manifold-base, four-way valves can be ganged to form common inlet, exhaust, and conduit channels. If more than one pressure is to be used, valves can be isolated and pressure fed from each end of mani-



Reliability is all-important...

AMERICAN STERILIZER SELECTS **Flexonics** BELLOWS





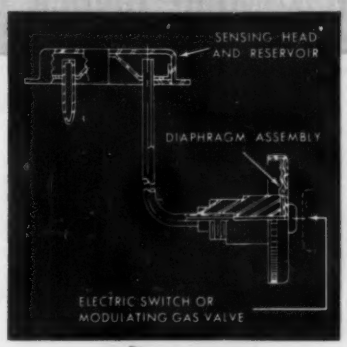
The steam pressure regulator that governs the operation of American Sterilizer Company's surgical supply sterilizers employs two Flexonics phosphor bronze bellows in vital spots. One positions the valve to control steam pressure; the other seals the valve stem for packless construction.

The equipment is operated by nurses and other non-mechanical personnel, so two considerations outweighed all others in the design of this valve: Complete safety, with zero maintenance, practically forever. These demands had to be met in the face of such design problems as elevated pressure and temperature, possible corrosive conditions, and providing sufficient travel for close control over a wide turndown. After exhaustive tests, Flexonics bellows are now standard on all Amsco sterilizers and autoclaves.

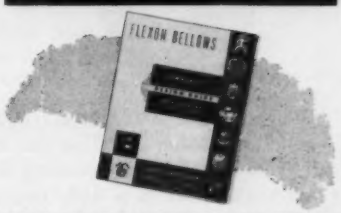
Flexonics has pioneered the design and manufacture of bellows from many new materials including Hastelloy. Come to Flexonics for the right bellows design in any application involving high pressures, high temperatures, extreme corrosive conditions, or other complex problems.

Flexonics temperature sensor gives automatic top-burner cooking ... and slashes original cost

For use in either gas or electric ranges, this top burner control, designed and manufactured by Flexonics for one of the country's leading range manufacturers, allows them to offer automatic top-burner cooking at less than half the cost of previous devices used for this application. Installation costs, too, are greatly reduced. Temperature sensing head and fluid reservoir are one small, rigid assembly, connected by capillary tube to the Flexonics metallic diaphragm that operates the modulating gas valve or electric switch. Flexonics design and production abilities can be turned to your own needs—usually with the twin results of improved functioning and lowered costs.



Flexonics Bellows are the simple, straightforward answer to many touchy design problems. For pressure or temperature measurement . . . shaft sealing . . . even low-torque rotary motion . . . call on your Flexonics Bellows expert. Or write for the Flexonics Bellows Design Guide, 20 pages of useful information.



F-810

Flexonics
corporation

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ont.

EXPANSION JOINTS · METAL HOSE · SYNTHETIC HOSE · BELLOWS · AERO/SPACE COMPONENTS

SUBSIDIARY OF CALUMET & HECLA, INC.

ATTACH TO YOUR LETTERHEAD—MAIL TODAY!

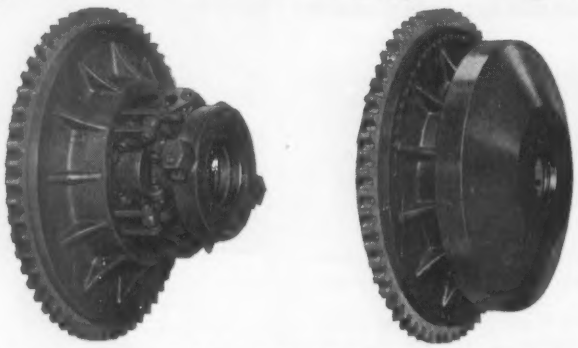
FLEXONICS CORPORATION
1339 South Third Avenue
Maywood, Illinois

Please send my personal copy of Flexonics 20 page Bellows Design Guide covering in detail Flexonics products and services for bellows applications.

DISCERNING DRAFTSMEN THE WORLD OVER DEMAND IMPERIAL THE WORLD'S FINEST TRACING CLOTH

Circle 544 on Page 19

Make Your Choice Of Clutch While Your Equipment Is In The Design Stage . . .



You can have your machine equipped with either our Over-Center Friction Clutch (left) or our Air-Operated Clutch (right). Each has its advantages depending on the use of the equipment. These clutches come in a wide range of sizes and with gear tooth or Flex-Disc. All are high quality, dependable clutches having low power losses, low upkeep, and long life. Readily adjustable for lining wear. Send for bulletins 5009 (Over-Center), 5011 (Air-Operated), or 5012 briefing our entire line of industrial clutches.

INDUSTRIAL CLUTCH CORP.
Waukesha Wisconsin

Circle 545 on Page 19

fold. First model in the 1/4-in. series is Model 551, a four-way unit. Construction permits interchangeable use of single or double-solenoid operation without demounting valve. Electrical wiring is greatly simplified. All manifold bases have both bottom and side ports with suitable plugs, permitting use either way. **Mechanical Air Controls Inc.**, 10030 Capital Ave., Detroit 37, Mich.

Circle 684 on Page 19

Electric Counters

for base, top, or panel mounting

Small, four-figure electric counters, Model 4-Y-9434, are available for base, top, or panel mounting with a panel plate. Counters operate dependably at speeds to 600 counts per minute. Standard models operate at 155 v ac, but they are also

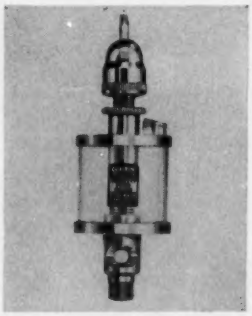
available for operation on dc. Counters are extremely accurate and long lived, because operation is based upon an escapement-drive mechanism. Driving parts are nylon with a hardened, stainless-steel drive shaft. One-piece, die-cast aluminum frame has a tight cover plate tongued to the frame to minimize entry of dust and foreign matter. Wheels are set up into the panel to give better visibility. **Durant Mfg. Co.**, 1933 N. Buffum St., Milwaukee 1, Wis.

Circle 685 on Page 19

Gravity-Feed Oiler

has needle-valve to control lubrication

Style EVO sight gravity-feed oiler provides accurate control of lubrication by an easy needle-valve adjust-



ment. Flow rate is positively locked by a knurled ring nut, once rate has been established and adjusted. Toggle-lever shut-off is provided, and uninterrupted metering of oil is assured by adequate venting. Sight feed window permits quick, convenient check of the oil-delivery rate. Oiler is available in both glass and unbreakable plastic reservoirs, each in six standard sizes. **Gits Bros. Mfg. Co.**, 1866 S. Kilbourn Ave., Chicago 23, Ill.

Circle 686 on Page 19

Pressure-Sensitive Tape

withstands temperatures to 248 F

Tesamoll 763, a polyurethane-foam-plastic pressure-sensitive tape, is fungus and mildew-proof, chemically inert, resistant to temperature, weather extremes, and most oils, and withstands temperatures to 248 F. Available in 30-ft rolls, ¼-in. thick and in a variety of widths, it is easily applied to any clean, dry surface by simply removing a vinyl-plastic liner exposing the pressure-sensitive adhesive. **United Mineral & Chemical Corp.**, 16 Hudson St., New York 13, N. Y.

Circle 687 on Page 19

Miniature Potentiometers

in ten and three-turn models

Micropot 7/8-in. diam, wirewound potentiometers, designated Series 2100, are available in ten and three-turn models. Assemblies withstand more than 1 million revolutions without exceeding total resistance or linearity tolerances. Total resistances to 100,000 ohms are offered. Two types of mountings, servo and bushing, are available. Either independent or zero-

Much stronger, they last longer when they're of reinforced TFE*

RULON®

Because Dixon's self-lubricating RULON has all the advantages of Teflon (low friction, chemical inertness, zero moisture absorption, extreme temperature range) PLUS a tremendous increase in mechanical strength and wear resistance, this engineered material is a natural for sealing applications. It exhibits no stick-slip characteristics . . . greatly reduces starting torques. And unlike rubber or leather, it retains its original dimensions, maintains positive contact with shafts or cylinder walls, and has infinite shelf life . . . being completely unaffected by weather, light, or heat. This material is now available with improved sealing action and at costs competitive with leather and rubber due to Dixon's new post-forming technique!

Want complete data? See our Catalog in Sweet's Product Design File, or ask for Brochure #9572.
DIXON CORPORATION, Bristol, Rhode Island

*DuPont Fluorocarbon Resin

Dixon Suppliers of basic shapes and fabricated parts in Rulon and Teflon

Circle 546 on Page 19

demand

THE VERY FINEST AND YOU GET IT FROM

B-H-E-W! If your job application demands precision hydraulic cylinders and you insist upon better on-the-job results, always *demand* B-H-E-W products! Only B-H-E-W offers designs and basic design techniques plus the added advantage of a complete staff of trained specialists to analyze your specific application. *You* benefit because *you* obtain B-H-E-W products at production prices which are precision-manufactured to produce the highest level of performance!

PRODUCTION PARTS SAVE YOU MONEY, DO THE JOB BETTER! B-H-E-W basic cylinders can easily be modified to fit your *specific* product applications. *You* benefit from production economies; you get custom-built cylinders!

BHEW's 3000 psi SERIES GENERAL-PURPOSE CYLINDERS, designed around component parts but custom-built to *your* specifications, are available in a variety of mountings, in sizes 1½" through 6", with adjustable or non-adjustable rod ends or without rod ends. These are rugged cylinders for O.E.M.

DISCUSS YOUR DESIGN AND APPLICATION PROBLEMS WITH US!

WRITE TODAY for free Hydraulic Cylinder Engineering Reference data. 78 dimensional basic designs for general purpose and special double- and single-acting cylinders. SAVE TIME!

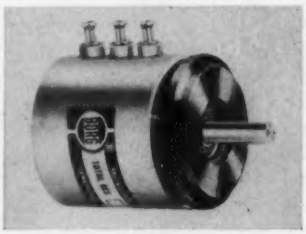
BH EW

INTEGRITY • CHARACTER • QUALITY

BENTON HARBOR ENGINEERING WORKS, INC.

622 Langley Avenue • St. Joseph, Michigan

Circle 547 on Page 19



based linearity is offered. All units withstand 1000 v runs applied between shaft and all terminals without damage, arc, or breakdown. **Borg Equipment Div., Amphenol-Borg Electronics Corp.**, 120 S. Main St., Janesville, Wis.

Circle 688 on Page 19

Filter Housing

features a straight-through design

Special feature of a new filter housing is straight-through design, permitting bowl to be removed from pipe line without disturbing pipe connections. Container design permits fabrication in a wide variety of materials with maximum cleaning ease and accessibility to all fluid passageways. Housing is generally furnished in Type-304 stainless steel. Corners are rounded, where possible, both inside and out-

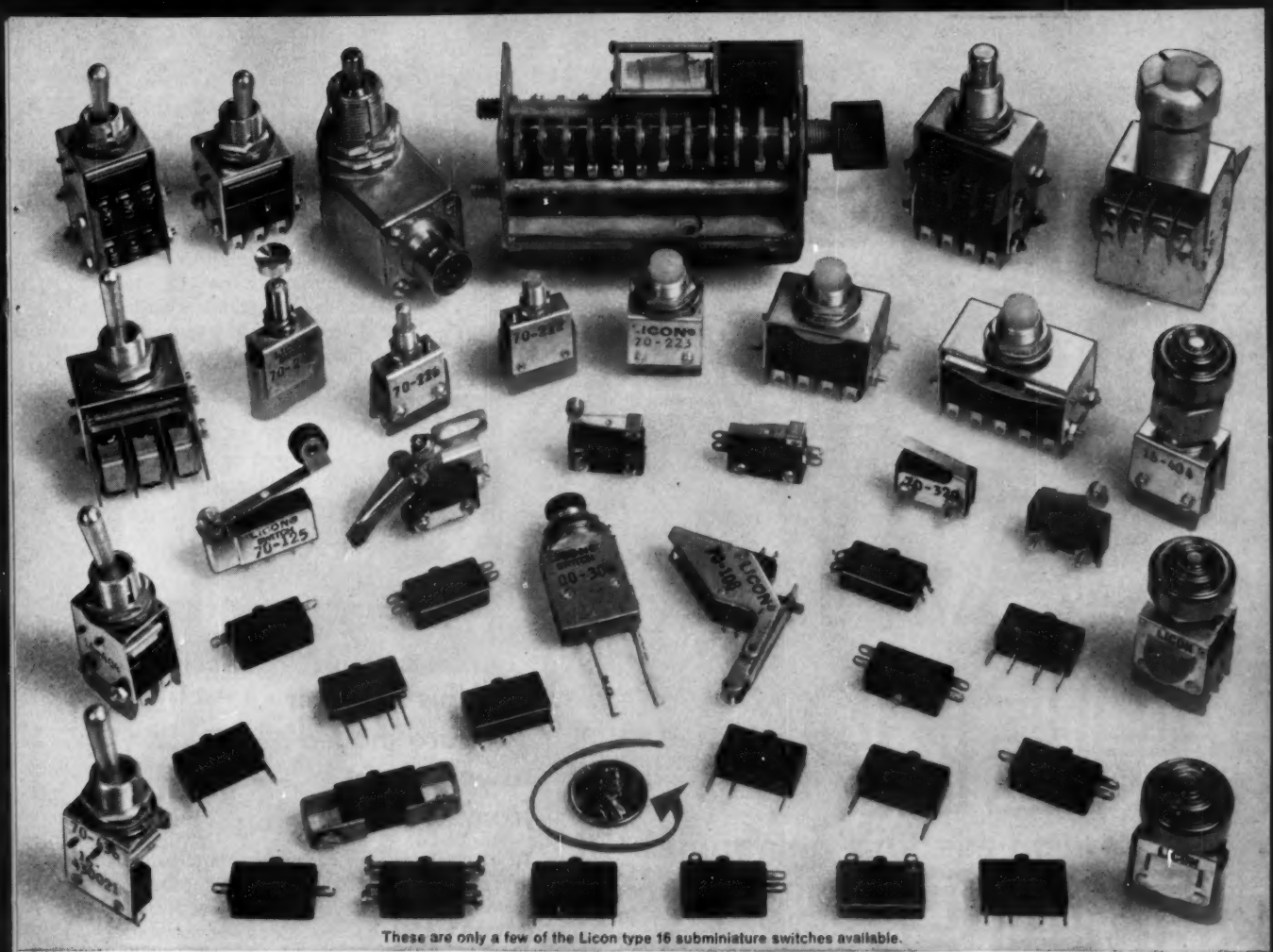
side. Quick-opening closure makes removel of bowl and replacement of element easy and quick. Housings can withstand up to 10,000 psi; 125 or 300 psig is standard. **Pall Corp.**, 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle 689 on Page 19

Control Synchros

are precision 3-minute units

Synchro transformers, transmitters, and differential transmitters, in all sizes from 11 through 23, have a



These are only a few of the Licon type 16 subminiature switches available.

LICON®

TYPE 16 SUBMINIATURE SWITCHES

PROVED BETTER 3 WAYS

LONGER LIFE . . . No other subminiature switch can equal the performance and long service life of the Licon Type 16. Only ¼" thick and 25/32" long, the Licon Type 16 delivers over 20,000,000 operational cycles without mechanical failure. This has been repeatedly test-proved. Quality and uniform dependability make the Type 16 superior to *any* subminiature switch.

HIGHEST ELECTRICAL RATING . . . The tiny Type 16 is rated at 10 Amps, 30 volts d-c inductive. This rating, the highest among subminiatures, is achieved with a unique double-break mechanism that effectively increases electrical performance, and life, as well as capacity. Arc energy and heat dissipation are distributed over two places, minimizing the possibility of contact weld. Double-break design offers multiple circuit possibilities not available in other subminiatures. The Licon Type 16 finds wide acceptance in aircraft and missile applications yet is economically adapted to industrial use. Its rating, dependability and performance equal those of a big switch, but its compact size makes it an excellent choice for use where critical space and weight limitations exist.

VERSATILITY . . . Type 16 switches come in reset, momentary, and specially engineered styles. Leaf spring, lever, roller, plunger or combination actuators are standard. Terminals may be solder, screw, or taper tab and may extend from the bottom, sides, or ends of the switch case. Variations of the Type 16 will be engineered to your specification.

THIS CATALOG IS YOURS *on request. It gives dimensional data and engineering "specs" on the Type 16 and the whole broad Licon line. Send for yours today.*

✻ TYPICAL PROVED APPLICATIONS . . .

Licon Type 16 subminiature switches are presently in use in missile detonators, sensing devices on automatic machine tools, automatic postal equipment, speed control devices, communication equipment, coin changer equipment, automatic door openers, relay actuation, and a host of airborne controls, including hermetic and environment-free units.

Licon

Standard Type 16 Switches and Actuators are available through your local Licon distributor.

DIVISION OF ILLINOIS TOOL WORKS

6606 W. Dakin Street, Chicago 34, Illinois

itw

Circle 548 on Page 19

YOUR DOLLAR CAN HELP THE U.S. TEAM WIN IN ROME

The possibility of the U.S. team winning the 1960 games in Rome this year depends to a great extent on what funds are available. The team needs money to help it achieve championship status. Many other countries, like Russia, finance their Olympic teams with government subsidies. The U.S. does not do this. Your dollar is needed. It is needed now to help the U.S. team win at Rome!

Get this souvenir postcard mailed to you direct from Rome, Italy

To acknowledge your contribution, arrangements have been made to send a special Olympic souvenir postcard to you or anyone you may specify. This postcard will bear a special Italian commemorative Olympic stamp. It will be mailed direct from Rome, Italy to you or anyone you specify . . . and will be autographed by leading members of the U.S. team.

The U.S. team needs funds to help them seek out the top U.S. athletes. To train them. To transport them to Italy. And to feed, clothe and house them while they are participating in the Olympic Games. You and others like you are the sole support of the U.S. team. Please mail your contribution today.

Donations are deductible on income tax returns.

MAIL YOUR DOLLAR TODAY!

Olympic, National Headquarters, Olympic House, 57 Park Ave., New York 16, New York

I want to help the U. S. team win the 1960 Olympic Games. Here is my $1.00 donation. Please put my name on the mailing list for the special Olympic autographed souvenir postcard.

*Name*_____

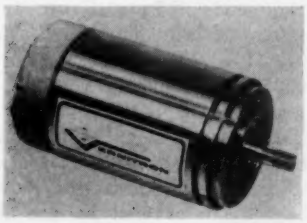
*Address*_____

*City*_____ *Zone*____ *State*_____

LARGER DONATIONS GRATEFULLY ACCEPTED

Preparation Costs of This Announcement Donated by These Chicago Companies: **J. M. Bundscho, Inc.,** *Typography* • **Schreiner-Bennett, Inc.,** *Art Work* **Rapid Copy Service, Inc.,** *Photostats* • **Rogers Engraving Co.,** *Engravings* • **National Electrotype Co.,** *Plates*

This Space Donated by MACHINE DESIGN



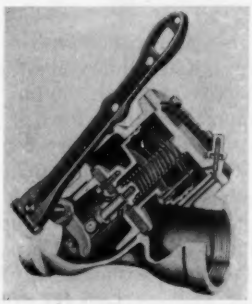
maximum electrical error of ± 3 minutes. Units are manufactured to MIL-S-2335, 12472, 16892, and 20708A, and FXS-1066 specifications. **Vernitron Corp.**, 127 Old Country Rd., Carle Place, L. I., N. Y.

Circle 690 on Page 19

Loading Valves

handle many liquids and chemicals

No. 417 or 418 loading valves have replaceable discs which permit handling a wide range of liquids and chemicals. Discs of neoprene, Compar, silicone, Teflon, and Viton-A are available in addition to standard Buna-N disc usually furnished. By replacing the Buna-N disc with one of the new discs, a standard loading valve can be adapted to many other fluids. Valves prevent shock, ending costly line damage, yet hold after-flow to a



minimum. They are available in 2, 2½, 3, and 4-in. sizes in aluminum or bronze. **OPW-Jordan**, 6013 Wiehe Rd., Cincinnati 13, Ohio.

Circle 691 on Page 19

Trimmer Capacitors

for printed-circuit mounting

Miniature trimmer capacitors, Mini-Trimmers, have smooth and linear fixed cavity tuning with 0-80 non-traversing screw. Change in ca-

An RMC thermometer is shown below as installed in Atlantic Refinery's Philadelphia Synthetic Ammonia Plant. RMC's superior dampening process provides the stamina necessary to meet the sustained accuracy requirements of operations such as this.

RMC dampening process insures sustained thermometer accuracy

RMC dial thermometers are thoroughly dampened with silicone on the bimetal element and a special precision-machined bearing on the shaft. The combined use of this dampening bearing *and* silicone makes RMC thermometers extra resistant to shock and vibration.

Facts you should know about proper dampening of bimetal thermometers

It is generally assumed that bimetal dial thermometers are dampened merely to prevent pointer oscillation when used on vibrating equipment. True, the prevention of pointer oscillation is necessary, but there are more important reasons for the use of dampening.

The primary reason is to preserve accurate calibration, especially in the lower temperature ranges where a thinner bimetal element is used. An *un*dampened bimetal element, when subjected to shock or severe vibration, would have a tendency to unwind slightly and throw the instrument out of calibration.

To prevent this, RMC thermometers are dampened by a patented process in which the bimetal element is coated with silicone. The silicone provides permanent protection for the critical bimetal element, holding the coil in place and preventing any unwinding or shifting action—thus helping to maintain calibration accuracy.

But RMC goes one step beyond silicone, with a specially designed bearing which even further dampens both shaft and coil. The bearing also serves as a better guide for the bimetal shaft to keep it perfectly aligned within the tube. Only RMC uses this extra dampening device in addition to silicone and the usual guide bearings.

It is the combined use of the special dampening bearing *and* silicone that makes RMC thermometers extra resistant to shock and vibration. You get this *only* in RMC industrial thermometers.

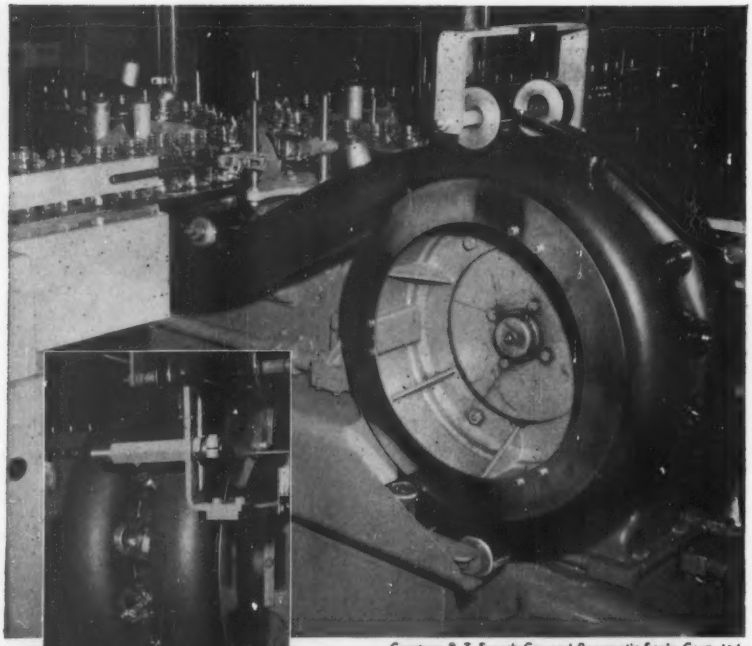
Write, wire or phone for general catalog. If yours is a special application, tell us your requirements—RMC engineers will work with you in solving it. Rochester Manufacturing Co., 229 Rockwood St., Rochester 10, N. Y. (Telephone: BRowning 1-2020).

RMC

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

ROCHESTER MANUFACTURING CO., INC., Rochester, N. Y.

Circle 550 on Page 19



Courtesy R. T. French Co. and Pneumatic Scale Corp. Ltd.

With the flexible sureness of human hands, parallel rubber tubes on this automated machine carry mustard jars through cleaning process in one of R. T. French's modern plants.

Pneumatic Rubber Tubes Solve Delicate Handling Problem

Guided by two large pulleys a pair of lightly inflated rubber tubes pick up glass jars from a flat conveyor at the rate of 240 per minute. With a cushion grip that conforms to these irregularly shaped containers the rubber tubes invert the jars and, without ever dropping one, carry them over jets of 60-psi air for scrupulous cleaning.

The success of this unique device depends on ability of the tubes to hold each jar with uniform, safe tension. To do this, the rubber tubes must retain their given size, shape and resilience while constantly stretching and flexing. Superior impermeability is also essential to prevent any dissipation of air even after long periods of use. Furthermore, the tubes must not kink or collapse when taking relatively sharp turns, especially with the thin tube wall and large cross section.

To save the customer extra equipment costs, the "stretch" of the compound was prefigured so that the manufacturing size would inflate to the proper working size without adjustments.

These exacting specifications require a precise blend of synthetics, processed and cured with the expert techniques of rubber specialists to assure a practical, functional rubber compound of exceptionally long working life.

This is another example of the complete engineering, laboratory and manufacturing service given to rubber parts produced by Continental. Next time your product calls for rubber parts, consult Continental—use this specialized help to save both tooling and material costs and still get rubber components that are practical, functional and dependable.

Another achievement in **RUBBER**

(CR) *engineered by* **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

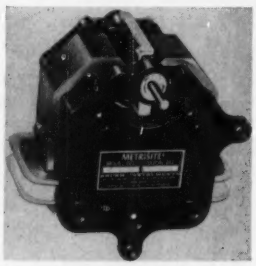
pacitance is 0.4 mmf per turn. Lengths of the four models are 27/64, 5/8, 13/16, and 1-3/32 in. Because the adjusting screw is always enclosed, lengths cannot be altered by tuning. Capacitance ranges are 1:4.5, 1:8.5, 1:12, and 1:18 mmf. Backlash and tuning breakage are avoided by use of a direct-traverse mechanism that also provides absolute torque control and automatic compensation for wear. **Corning Glass Works,** Corning, N. Y.

Circle 692 on Page 19

Angular-Motion Transducer

operates at 60 cps

Metrisite angular-motion transducer for operation at 60 cps converts to voltage angular motions up to ±40 deg with a linearity better than 0.25 per cent. Designated Type 34A, unit is designed for measurement of high-accuracy data under rugged



environmental conditions in both industrial and military applications. Unit provides high output with minimum reactive force. Scale factor is 0.57 v rms per deg, and null voltage is less than 0.1 v. Transducer measures 3 x 2⅝ x 1⅞ in. and weighs 20 oz. **Brush Instruments Div., Clevite Corp.,** 37th and Perkins, Cleveland 14, Ohio.

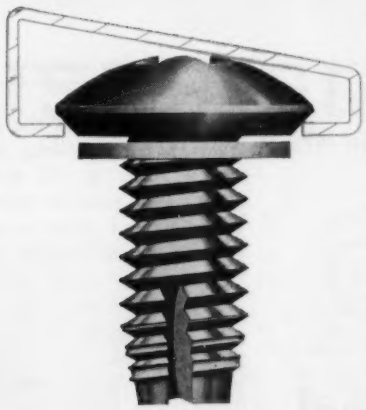
Circle 693 on Page 19

Electric Motors

have new epoxy insulation system

Epoxy insulation system for electric motor coils, known as Epa-Seal, is applied to both random and form-wound motors of 1 to 500 hp. For form-wound motors, Epa-Seal epoxy resin is applied to core and frame before winding. After all coils are installed, the entire wound stator undergoes vacuum-pressure process

Circle 551 on Page 19



how much did Philco save per unit with this Shakeproof idea?

5¢?–23¢?–57¢?*

*answer 57¢

Ideas like this are important to you whether you make refrigerators or not. This one is typical of Shakeproof ingenuity in research and development that daily creates new ideas for industry . . . ideas to improve product performance, to speed assembly operations, to lower total costs. It represents the kind of creative engineering characteristic of Shakeproof designers and engineers who are available to visit your plant, to study your assembly methods and problems and to design ingenious new fastenings for your specific application.

The idea that is saving money for Philco is the Shakeproof® Trim Mounting Thread-Cutting Sems designed so that decorative molding strips can be snapped into place over the fastener. This eliminates a previous three-part fastening operation and the related disadvantages of locating and holding the bolt while the nut is applied from the opposite side. Shakeproof's Trim Mounting Sems cuts its own thread and eliminates the need for a sealant, too, as the nylon washer is drawn down tightly to serve as an effective sealer.

WRITE FOR THIS FREE BOOKLET

It gives examples of Shakeproof fastening ideas, how they are being used by leading manufacturers in every industry, and how Shakeproof fastening ideas can work for you.

itw

SHAKEPROOF

"FASTENING HEADQUARTERS"®

DIVISION OF ILLINOIS TOOL WORKS

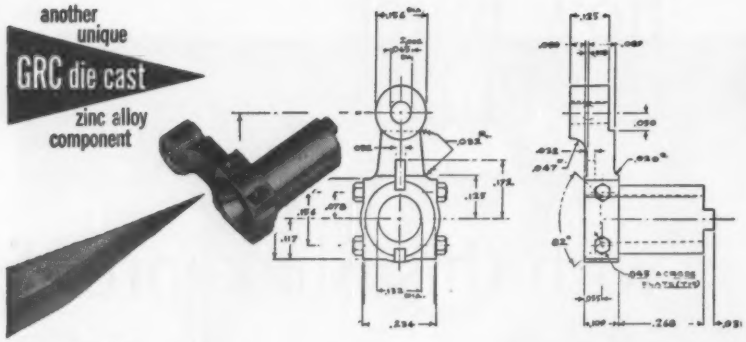
St. Charles Road, Elgin, Illinois

In Canada: Shakeproof/Fastex

Division of Canada Illinois Tools Limited, 67 Scarsdale Road, Don Mills, Ontario

LOOK TO SHAKEPROOF – THE LEADER IN FASTENING

Circle 552 on Page 19



GRC die casting helps Lionel achieve tiny part authenticity

This intricate toy crank was die cast in zinc alloy by GRC in a single automatic operation. Cost? Little more than $5.00 per thousand in lots of 500,000. Result? Produced quicker and more economically than Lionel could themselves. Less than half an inch overall, it is typical of the many small (maximum is 1¾" ½ oz., no minimum) parts problems solved by GRC's unique techniques. Gries' specialized machines deliver parts ready for use—uniform, accurate, clean —no trimming, no assembly, no scrap loss.

If you have a small parts problem, write, wire or phone for GRC's die casting bulletin or send prints for quotation.

25 years of progress in tiny parts

GRIES

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

32 Second St., New Rochelle, N. Y., NEw Rochelle 3-8600

Circle 554 on Page 19

HUMAN-FACTORS ENGINEERING

by John D. Vandenberg and C. Thomas Goldsmith

Thirty-one pages of helpful information for the designer contending with human limitations and capabilities. Special emphasis is given to design for vision, hearing, muscular performance and body dimensions in relationship to man-machine efficiency **$1.00 per copy**

A MACHINE DESIGN REPRINT

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which impregnates the coils, eliminates internal voids, and applies epoxy resin to all external surfaces. For random-wound motors, entire wound stator is encapsulated by a vacuum-pressure system that drives epoxy resin deep into the coil slots, filling them completely. **Crocker-Wheeler Div., Elliott Co.,** Jeannette, Pa.

Circle 694 on Page 19

Geared Servo Motor

size-8 unit has high torque and low inertia

Geared servo motor, Size 8, is a small, lightweight unit characterized by high torque and low inertia. Centered-shaft gearheads are available in 28 ratios from 7.62:1 to 1254:1, and eccentric-shaft gear-

heads can be provided in ratios from 7.62:1 to 903:1. Motor is ruggedly constructed and operates in ambient temperatures of −54 to +105 C. **Kearfott Div., General Precision Inc.,** 1150 McBride Ave., Little Falls, N. J.

Circle 695 on Page 19

Pump-Motor

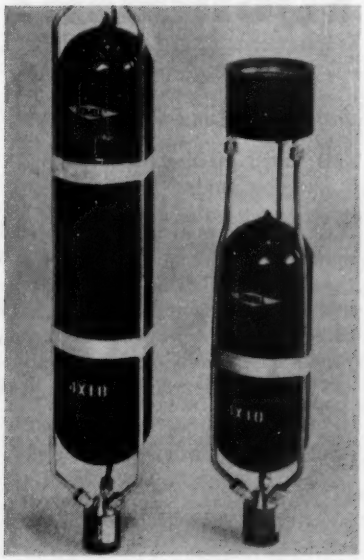
operates from 12-v battery

Series T pump-motor combination consists of 0.07-hp, series-wound, dc motor, rated for 2300 rpm, combined with a special pump with a capacity of 25 gph at 60 psi. The two are connected by a bracket and coupling developed to provide most perfect alignment possible, in order to obtain minimum power consumption. Operating from a 12-v battery, unit is designed for water and similar fluids. Pump is of noncorrosive construction, incorporating a bronze body, stainless-steel rotor, carbon vanes, and Graphitar bearings. **Tuthill Pump Co.,** 939 E. 95th St., Chicago, Ill.

Circle 696 on Page 19

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING



NEW WAY TO TICKLE A "TRICKLE" WELL

For some centuries now, great bangs around the globe have borne witness to man's sometimes happy faculty for putting to work the phenomenon we call "explosion."

Now we are finding ways to make use of *im*plosion. And glass is helping us.

Supposing your oil well starts to ooze instead of gush. You take one of the devices shown above and lower it into the well. Fill the hole with fluid and apply pressure. When the psi reach a set level, you get a squoosh and then a whoosh and then—with luck—a gush of oil.

The squoosh signals an implosion; the whoosh, a counteracting explosion in the fluids. Working together, the two forces develop pressure waves up to 20,000 psi, usually enough to fracture the surrounding strata and to stimulate the flow of any oil present in the formation.

The service using these capsules is called Rockshock;* it was developed and is offered by Dowell Division of The Dow Chemical Company. The capsules are made from PYREX® brand glass blanks which we supply. The capsules are evacuated to extremely low pressures.

We make the composition of the glass blanks and their wall thicknesses to exactly the right specifications so that the capsules will implode at specified pressures.

We make the glass so that it will *dice* when it implodes, disintegrating instantaneously to pieces small enough to pass through valves and pumps without damaging them.

At the same time, we make the glass sturdy enough so that you can handle the capsules used in Rockshock above ground with as much safety as glass bottles.

Dowell can tell you more about Rockshock. They are in Tulsa, Oklahoma. We can tell you more about the marvels of glass . . . say, in our Bulletin B-83, titled "Properties of Selected Commercial Glasses." We are in Corning, New York, and can be reached by coupon.

*Dowell Service Mark

STEAM GAUGE THAT WORKS LIKE A TRAFFIC LIGHT

When you see red, you're looking at live steam. When you see green, you're looking at water.

It's as simple as that with this new Multi-Port gauge from the Diamond Power Specialty Corporation.

Like so much that's simple, this takes a fairly complicated system of optics, for which we supply the glass.

Like so much that's complicated, this optical system takes advantage of a simple fact, namely, water and steam have different refractive indexes.

At the rear of the gauge a group of sealed-beam lamps (we probably made the glass for these, too!) throw light on two colored pieces of glass. One is red, the other is green. If the light then passes through steam, only the red portion gets through to the viewing port. Vice versa for water. If the water level falls half way up a port, you see both red and green with a sharp line of demarcation at exactly the right level.

You can see the gauge in the dark. Since light has the swiftest of all movement, there is absolutely no time lag when the steam level changes.

Aside from its optical properties, the glass we provide has to take the thermal shock of live steam, the corrosive environment of steam and water, and pressure up to 3000 psi.

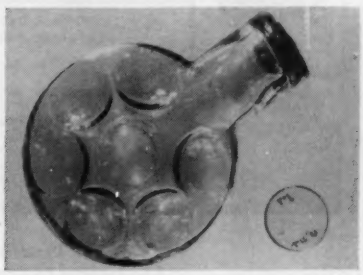
Actually, these are simple conditions for us to meet, as you'll discover, if you ever have occasion to put one of our glasses to work.

Bulletin IZ-1, "Designing with Glass for Industrial, Commercial, and Consumer Applications," can help you spot such occasions. The coupon will fetch you a copy.

WHY EYEGLASS LENSES DON'T COME IN BOTTLES ANY MORE

In 1912 this flask was a marvel of mass production. With just a few good puffs one of our glassblowers could produce blanks for a dozen or more eyeglass lenses.

Now look at the lens blank in the corner of the picture. It has the stamp of technology all over it. Code letters and numbers. Nicely finished edges. Each one like the other.



Now we have machines to stamp out lens blanks . . . even bifocal lens blanks . . . by the millions without a glassblower drawing breath.

A perfect example of our willingness to sacrifice the romance of handcrafting to the sheer economy and efficiency of machinecrafting whenever it will benefit our customers.

The only interest we expect you might have in all this is in this simple fact: we have *two* kinds of versatility to sell. The versatility of glass itself. The versatility of methods in manufacturing from glass.

We can cast giant mirrors and windows for radioactive cells, blow delicate bubbles for lab ware, press or roll great masses for items needed in large quantities in a hurry . . . in short, we can put to work practically every manufacturing method known to man to put your product in glass.

"This Is Glass" is a booklet that tells more about these methods and glass itself. It's in the coupon.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS, 52 Crystal St., Corning, N. Y.

☐ B-83; ☐ This Is Glass; ☐ IZ-1

Name..... Title.....

Company.....

Street.....

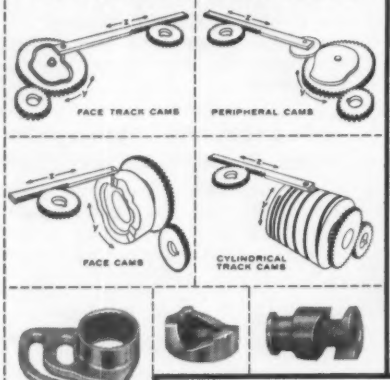
City..... Zone..... State.....

Circle 555 on Page 19

CAMS

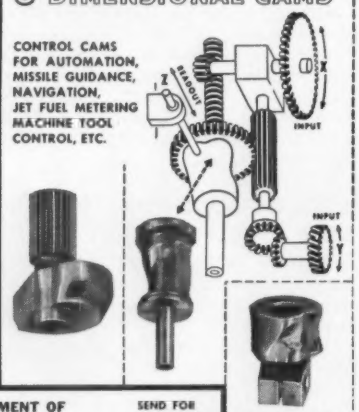
✓ 2 & 3 DIMENSIONAL MASTER CAMS
✓ EXPERIMENTAL CAMS
✓ PRODUCTION CAMS

2 DIMENSIONAL CAMS



3 DIMENSIONAL CAMS

CONTROL CAMS FOR AUTOMATION, MISSILE GUIDANCE, NAVIGATION, JET FUEL METERING MACHINE TOOL CONTROL, ETC.



DESIGN & DEVELOPMENT OF SPECIAL CAM CONTOURS

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THE PARKER- HARTFORD CORPORATION CAM DIVISION
700 FRANKLIN AVENUE • HARTFORD, CONNECTICUT

Circle 556 on Page 19

COST AND SERVICE STORY

behind Reese Powdered Metal Knobs for Bernz-O-Matic Ceramic Grill

From John B. Spiggle, Purch. Agent for the Otto Bernz Co., Inc.: "Our present brass powdered metal knob was evolved from a smaller knob that was re-designed from a screw machine part to reduce cost. When we required a larger but similar knob on another product, we immediately thought of powdered metal. Reese received the order for this new part because their price and delivery were better than others who had quoted. We have continued to do business with Reese because their prices have been in line and their service and quality better than our other sources for powdered metal parts."

FREE BROCHURE "How to Cut Precision Parts Cost with the Remet Powdered Metal Process" shows how the Reese Corp. can help you. Send for your copy today.

Remet

REESE METAL PRODUCTS CORPORATION
537 Howard Ave., Lancaster 11, Penna.

Gears • Pinions • Cams • Ratchets
Oilless Bearings • Bushings • Machine and Structural Parts in
COPPER • BRASS • IRON • ALLOY STEEL • NICKEL SILVER • COPPER INFILTRATED IRON

Circle 557 on Page 19

ENGINEERING DEPARTMENT

EQUIPMENT

Automatic Lead Pencil

is suited for use with lettering guides, templates

Mark V automatic propelling lead pencil is 6 in. long and weighs less than ½ oz. It has a nonrolling hexagonal barrel with knurled, tapered finger grip. For one-hand operation, pencil has a quick-acting, pushbutton, fully automatic lead feed

(breech-loaded through top). Fine-line pencil is offered in jet-black finish, with color-coded caps indicating degree of lead hardness. Standard or special pocket models are available. Refill leads are furnished in nine degrees of lead hardness from 3B to 4H. Alvin & Co. Inc., Windsor, Conn.

Circle 697 on Page 19

Miniature Flowmeter

for low-flow applications

Inexpensive, miniature flowmeter, Minirator, measures low flow rates of either liquids or gases. Unit provides superior readability and accuracy, and is excellent for analytical applications in addition to normal process uses. Standard parts are interchangeable for varying capacities. Tube is snap-in type, permitting a change in range in a few sec-

SPICER RUBBER ELEMENT SHAFTS CAN HELP YOU SOLVE YOUR TORSIONAL RESONANCE PROBLEMS

If you are faced with the problem of torsional vibration from impulses within the operating range, Dana engineers may be able to help you solve your design problems.

Spicer resilient propeller shaft assemblies have been used successfully for years in rapid transit cars, street cars, engine dynamometer, truck, bus, earthmover and passenger car applications to solve difficult torsional problems.

Spicer rubber-cushioned shafts make it possible for design engineers to "tune out" the vibration and thus produce commercially acceptable installations.

Spicer rubber-cushioned propeller shafts offer these additional advantages:

1. The torsional flexibility limits the effect of high impact loads resulting from rough shifts and other sudden torque changes.
2. The cushioning effect prevents clatter, rattle, and backlash noises.
3. Increased life of bearings, gear teeth, splines, and other components due to the reduction of high impact and torsional loads.
4. Reduction of noise transfer.
5. Axial flexibility to cushion forces resulting from length changes.

Product knowledge and years of experience are available to you through Dana engineers to help solve your torsional problems. Contact them today.

International 295 Payscraper, equipped with a Spicer rubber element shaft, at work on the Interstate Highway System.

DANA Spicer

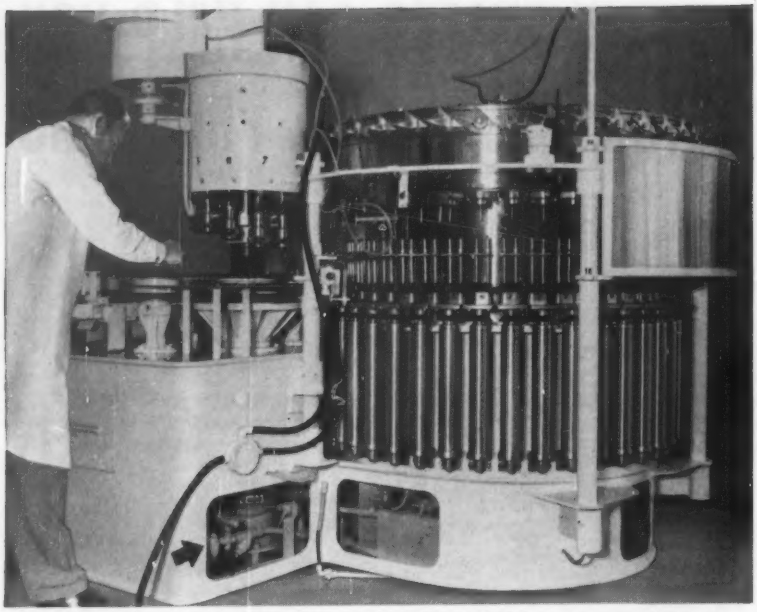
DANA CORPORATION

Toledo 1, Ohio

SERVING TRANSPORTATION—Transmissions Auxiliaries • Universal Joints • Clutches • Propeller Shafts • Power Take-Offs • Torque Converters Powr-Lok Differentials • Gear Boxes • Forgings Axles • Stampings • Frames • Railway Drives

Many of these products are manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario

Circle 558 on Page 19



CEM "Uni-Blend" Filler manufactured by Crown Cork & Seal Co. for beverage industry.

Crown Cork & Seal Co. put B&S Pumps in 50 new machines - never had a failure or a complaint!

The whole top of this new bottle-filling machine revolves on a thin film of oil that is maintained in a large hydrostatic bearing by a pump. The same oil acts as a seal for air, being distributed to bottle-lifting cylinders right through the bearing.

B&S No. 111 ¼ hp motor-driven gear pump (arrow) supplies oil at 35 psi to hydrostatic bearing.

It's easy to see that this manufacturer can't take chances on a pump failure; if the pressure drops, the whole machine shuts down. At customer production rates of up to 320 bottles a minute, it would be a very costly failure.

That's why Crown Cork & Seal Company uses Brown & Sharpe pumps. They are built to the high quality standards of machine tools.

Of the Brown & Sharpe pumps Crown has put in 50 new machines — not one has ever failed or caused a complaint.

For trouble-free pumps in *your* machines—contact Hydraulics Division, Brown & Sharpe Mfg. Co., Providence 1, R. I., or your nearest B&S engineer-representative.

Brown & Sharpe
PRECISION CENTER

Circle 559 on Page 19

onds without tools. Tube floats between end fittings on O-ring seals and is free from pipeline vibrations and misalignment stresses. End fittings can be rotated through a full 360-deg for ease in mounting, and meter can be surface or flush mounted on a panel or installed in line. Unit is available with 1½ or 4-in. scales, with or without integral needle valve, and with brass or stainless-steel end fittings. **Fischer & Porter Co.**, 551 Jacksonville Rd., Warminster, Pa.

Circle 698 on Page 19

Pressure Transducer

miniature unit is unbonded strain-gage type

Accurate, reliable pressure transducer, Type 4-325, is only ¾ in. in diam, 1/3 in. high, and 8 grams in weight. Unbonded strain-gage unit is for use where accurate pressure measurements must be made under extreme conditions in a minimum of space. Pressure ranges are

from 10 to 100 psi absolute, 2 to 100 psi gage, and ±2 to ±50 psi differential. Pressure limit is 1.5 times rated pressure without calibration shift, and two times rated pressure without permanent damage. Transducer operates without damage at temperatures from −320 to +300 F. Rated and maximum excitation are 5 and 12 v rms. Carrier frequency is 0-20 kc. **Consolidated Electrodynamics Corp.**, 360 Sierra Madre Villa, Pasadena, Calif.

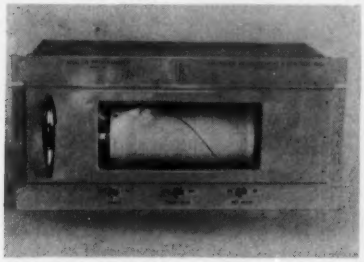
Circle 699 on Page 19

Analog Programmer

generates voltage directly from graph

Model 750 analog programmer is an arbitrary-function generator wherein any single valued function (y) drawn on graph paper with

conductive ink is converted to a proportional voltage as a function of time (x). Unit has an accuracy of ±0.5 per cent and response time of less than 10 mu sec to full scale. At any specific instant of time, output voltage (y) is proportional to the drawn curve. X axis varies linearly with time when drum is driven by constant-speed synchro-



nous motor provided. When used with a servo motor, drum position can be a function of an independent variable. **American Measurement & Control Inc.**, 240 Calvary St., Waltham 54, Mass.

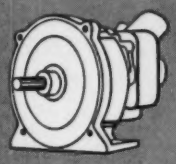
Circle 700 on Page 19

Recorder-Reproducer

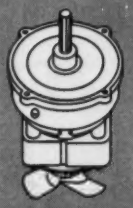
is all-solid-state unit in small package

Type PR-2300 all-solid-state magnetic-tape recorder-reproducer offers features of larger instruments in a small package than can be transported easily or mounted in standard racks. Tape-transport system is mounted in an aluminum carrying case. For vertical mounting in a 19-in. rack, transport can be mounted either in or out of its case; for horizontal mounting, transport is removed from the case. Electronics are mounted in a matching case. Each case holds up to 14 plug-in record or reproduce amplifiers. One or two of these can be fastened to the transport case to build one integrated system. Up to 14 channels of direct record or wide-band fm analog data can be recorded and played back bidirectionally. Unit records and reproduces at speeds of 60, 30, 15, 7½, 3¾, and 1⅞ ips. Unit operates on 115-v, 60-cycle current at temperatures from 40 to 125 F. **Consolidated Electrodynamics Corp.**, 360 Sierra Madre Villa, Pasadena, Calif.

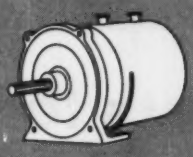
Circle 701 on Page 19



Standard model with base for horizontal, vertical or angular mounting.

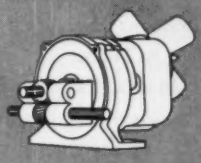


Standard model without base for face mounting.



Standard model with motor cover; ventilated or non-ventilated.

This model provides up to 300 lb. in., starting torque, small enough to fit the hand.



Right angle shaft, single or double extension at 3, 6, 9 or 12 o'clock.

"SPECIAL" fhp GEARED MOTOR PROBLEM?

HERE'S YOUR ANSWER—

MK MERKLE-KORFF

From 800 down to 1/5 R.P.M., or lower; for continuous, intermittent and reversing applications; with or without cooling fans, brakes and motor covers—you get more torque per pound and per dollar with Merkle-Korff's long experience and dependability.

HUNDREDS OF MODELS

Merkle-Korff geared motors have forty-nine years of progress behind them—and you! Excellent basic design, know-how gained in producing many *millions* of geared motors and *billions* of gears assure you that Merkle-Korff has the motor you need—or can design and build one for you in record time.

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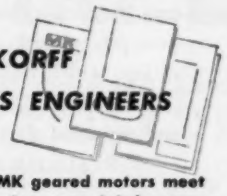
Horizontal, vertical, side wall, base or face mounting—any way you need your motors Merkle-Korff can supply them.

VARIETY OF MOTORS

Do you need perfect timing? Reversing motors? Universals? Starting torques equal to or exceeding running torques? Do you need more power in the smallest package and at the lowest cost?

Merkle-Korff probably has the answer ready for you now. Investigate. There is no obligation.



LET MERKLE-KORFF APPLICATIONS ENGINEERS HELP YOU!

Standard models of MK geared motors meet hundreds of OEM requirements. Ask for complete engineering data.

MK Applications Engineers are at your service if you have unusual requirements. They welcome "problems"; they enjoy solving them. Write us today.

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MERKLE—KORFF MK GEARED MOTORS

Circle 560 on Page 19

unusual magnets for unusual applications

Shape is not the only unusual thing about these ceramic magnets! Most important is *how* and *where* they can be used. For *Ceramagnet*® is a basic, new design material — not a substitute for conventional metallic magnets. It allows magnetism to be creatively applied in new and better ways — usually at low cost — to literally hundreds of products from small motors, generators, coupling drives, holding devices, and filters, to lightning arrestors, sonar equipment, switches, and many others.

Ceramagnet permanent magnets are electrically non-conductive and chemically inert. They may be used without keepers and pole pieces, with many poles on one face, and under other conditions which would quickly demagnetize conventional magnets.

Where can Ceramagnet fit into your application? For ideas and technical data, send for Stackpole Bulletin RC-12A.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

STACKPOLE *Ceramagnet*®

CERAMAG® FERROMAGNETIC CORES • SLIDE & SNAP SWITCHES • VARIABLE COMPOSITION RESISTORS • FIXED COMPOSITION CAPACITORS • BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT • ELECTRICAL CONTACTS • GRAPHITE BEARINGS & SEAL RINGS • COLDITE 70+® FIXED COMPOSITION RESISTORS • AND HUNDREDS OF RELATED PRODUCTS

Circle 561 on Page 19

THE ENGINEER'S

Library

Recent Books

Technical Communication. *By George Harwell, associate professor of speech, Duke University; 342 pages, 5¾ by 8½ in., clothbound; published by and available from The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; $5.00 per copy.*

This book contains practical information for those who must communicate technical material by letter, report, article, or speech. During the initial approach, underlying principles are stressed instead of a variety of surface practices.

Techniques of organization and presentation are discussed first. Then, the business letter, formal and informal reports, technical articles, and oral communication are thoroughly covered.

Mechanism. *By Virgil Moring Faires and Robert McArdle Keown; 332 pages, 6¼ by 9¼ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42 St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.50 per copy postpaid.*

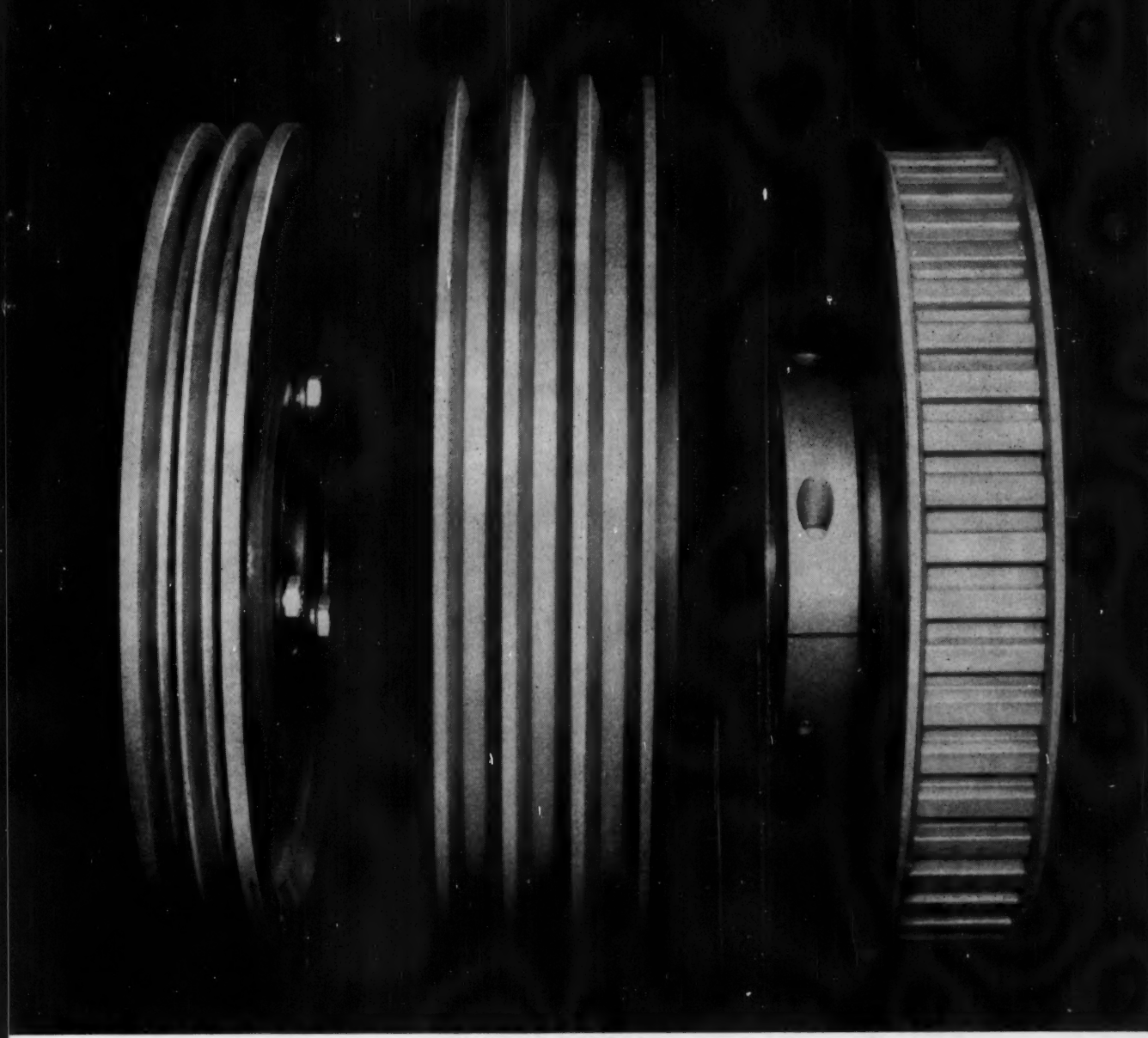
Practical treatment of the more common engineering problems on motion is presented.

In this fifth edition, special topics are selected for intensive discussion. These include the principle of jerk as applied to cams, cycloidal motion, improved cam design, Geneva-mechanism design, analysis of gear-tooth action, and universal joints. Also new in this edition are problems for graphical solution.

Special Functions. *By Earl D. Rainville, professor of mathematics, University of Michigan; 365 pages, 6¼ by 9½ in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$11.75 per copy postpaid.*

Special functions frequently encountered in engineering, physical, and chemical applications are emphasized. Functions of the hypergeometric type are thoroughly covered, and a comprehensive treat-

Circle 562 on Page 19→



THE NEW MULTI-WEDGE DRIVE SHEAVE | MULTI-V DRIVE SHEAVE | POSITIVE DRIVE PULLEY

FIRST, LOOK AT THREE

Measured by horsepower handled, the three wheels shown are the same. But Multi-V (long the industry favorite) is bulky, as compared with the new lighter, equally strong Multi-Wedge Drive. And the Positive Drive combines advantages of the chain and gear with the advantages of the belt.

For all three, even in fractional sizes, Worthington supplies the tapered, split QD hub with the Golden Screws. Or, of course, it supplies bored-to-suit hubs for special applications. And for every drive, from 1/20 hp to 600 hp or more, the proven Worthington-Goodyear belts are supplied. In fact, the QD hub plus these belts in any of the above three drive types make them most compact, flexible and long-lived.

Which drive you choose is up to you. But don't toss a coin. To help you decide, Worthington has just issued new engineering manuals on all three drives, including "how-to-figure-it" information. For low horse power drives, get the "Fractional HP" manual. Ask the Worthington distributor listed in the Yellow Pages for the manual(s) you want. Or send the coupon listed below.

WORTHINGTON CORPORATION
Section 79-33, Oil City, Pa.

Please send me the engineering manuals checked here.

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MILITARY MOTORS

are a specialty at Peerless Electric

A military motor has to be fail-proof under the toughest service demands. If not, you take a big loss. The expense of removing a faulty motor for repairs is far greater than it would cost to get a Peerless Military Motor in the first place.

Peerless Electric military motors are available in drip-proof, splash-proof, totally enclosed, spray-tight and water-tight construction from ½ to 30 HP. They meet specifications of ABS, U. S. Coast Guard, MIL-M-17413 (DC), MIL-M-17060A and B, MIL-M-17059 (AC), and AIEE 45. With standard or special mountings and features, they serve at land-based radar installations and aboard vessels throughout the world.

What's your military motor problem? We'll work with your engineers to produce the motor that shrugs off heavy duty and keeps right on delivering . . . that best serves your needs and specifications. Write: *Peerless Electric Division, H. K. Porter Company, Inc., W. Market St., Warren, Ohio.*

PEERLESS ELECTRIC DIVISION

PORTER

H. K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

ment of generating functions is presented. More than 50 special functions are discussed.

Association Publications

Cast Bronze Bearing Design Manual. *By Harry C. Rippel; 72 pages, 8½ by 11½ in., clothbound; published by and available from Cast Bronze Bearing Institute Inc., 1604 Chicago Ave., Evanston, Ill.; $2.00 per copy.*

Latest theoretical and experimental information on bronze bearing design is presented. Design techniques are simplified, and cumbersome trial-and-error methods have been eliminated.

Some topics discussed are viscosity and lubricants, bearing bronze selection, grooving specifications, techniques for supplying lubricant, and bearing fabrication and assembly.

A series of articles which appeared in the Sept. 17 to Dec. 10, 1959, issues of MACHINE DESIGN ("Design Manual: Cast Bronze Sleeve Bearings") was based on this book.

Elevated-Temperature Properties of Wrought Medium-Carbon Alloy Steels—STP 199. *By Ward F. Simmons and Howard C. Cross; 128 pages, 8½ by 11 in., paperbound, stapled; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $4.25 per copy.*

Strength data for medium-carbon alloy steels are presented for temperatures up to 1400 F. Included are tensile strength, 0.2 per cent offset yield strength, elongation and reduction of area, stresses for rupture at various periods of time, and stresses for various creep rates.

1959 ASTM Proceedings, Vol. 59. *1424 pages, 6¼ by 9¼ in., clothbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $12.00 per copy.*

This volume contains the summary of proceedings of the ASTM 62nd annual meeting, June 1959, and the summary of proceedings of the third Pacific area national meeting, September 1959. Programs for each session are listed by title and author.

About 70 reports of technical committees and 44 technical papers

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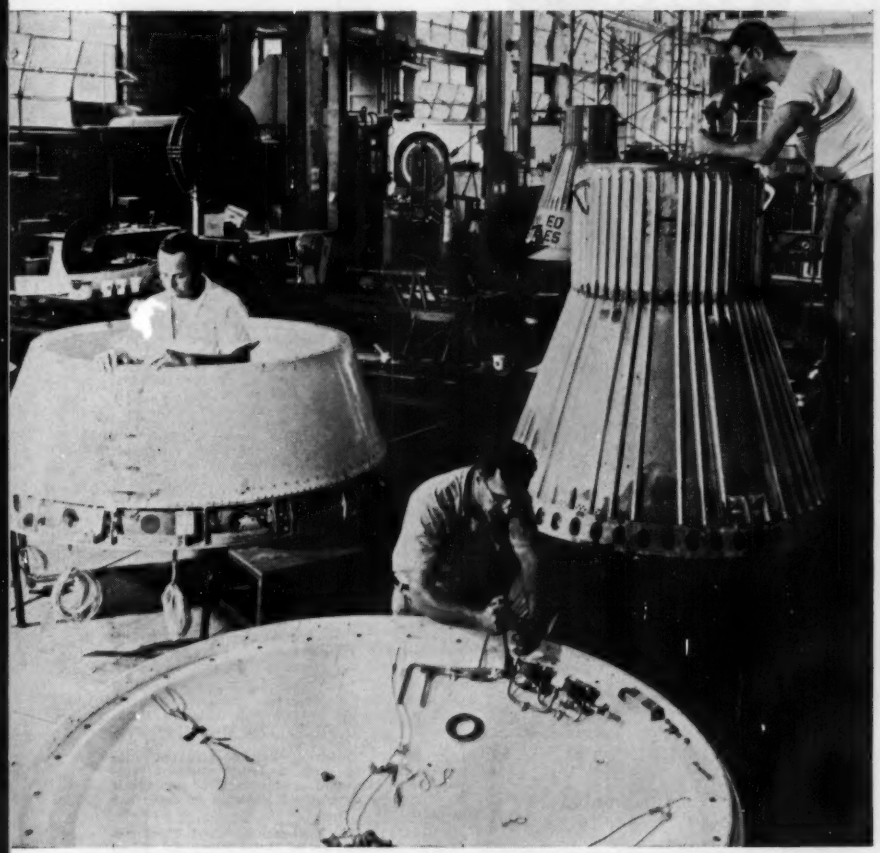
Circle 564 on Page 19→

Product-Design
BRIEFS
from Durez



MORE ABOUT UNCLE'S MONKEY

Uncle Sam's first astronaut was a rhesus monkey, also named Sam, who took a 55-mile-high ride in a vehicle called Little Joe. It is Little Joe we're concerned with.

Specifically, with the part of Little Joe made from heat-resistant Hetron® polyester resin.

The full-scale Little Joe capsule is 9½ feet tall, 20 inches across the top and 6 feet across the rounded base. The bottom portion of this capsule consists of a heat-absorbing shield of glass-reinforced Hetron. Its several layers add up to an inch of thickness.

Hetron was chosen after intensive research because it provides an unusually high degree of inherent heat resistance, heat stability and fire resistance. All of these properties are important in coping with heat generated by atmospheric friction at escape velocity. Ease of fabrication was pretty important, too.

The large photo shows the two Hetron portions of the capsule: the bottom, in foreground; the heat-shield, at left.

Not only Uncle Sam's sophisticated scientists, but also the more prosaic industrial designers are interested in Hetron. It offers great promise in many different applications.

For example, it makes possible small boats that are fire-retardant. Because it is highly resistant to many acids, it finds wide use in scrubbers, ductwork and similar places where corrosive fumes quickly destroy other materials. It's being used for skylights on piers. One company even enclosed an entire building with it.

Hetron can by no means be considered a cheap substitute for other materials. Designers have been impressed with it and have used it simply because it performs its function better than any other material they might have used. Sometimes it costs less than other materials. Sometimes it costs more. But, in either case, it does things better, longer or more safely than anything else. We've got a data file on it if you're interested. Ask for Hetron File A.

A THOUGHT FOR USERS OF DIE CASTINGS

When you put these seven parts together, you get a highly efficient low-cost pump for emptying drums of gasoline, lube oil or chemicals.

The manufacturer used to die cast these parts. Now he has them molded from a Durez phenolic. The switch to molding from die casting eliminated many finishing and assembly operations. Even the fine threads on one of the parts were flawlessly molded.

The switch to phenolic from aluminum added greater corrosion and chemical resistance. Being non-metallic, phenolics also prevent sparking and minimize the risk of handling volatile liquids.

For more facts about molding with versatile Durez materials, ask for Bulletin D400.

For more information on Durez products mentioned above, check here:

- ☐ Hetron polyester resins (File A)
- ☐ Phenolic molding compounds (illustrated Bulletin D400)

Check, clip and mail to us with your name, title, and company address.
(When requesting samples, please use business letterhead.)

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HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

UNITCASTINGS provide answer for difficult parts problem!

Again, Unitcast Foundry Engineering proved invaluable in producing this hydraulic valve body casting.

Faced with the necessity of a durable, more compact unit, the customer investigated the advantages of *cast steel.* Firm specifications included small and irregular internal passages that were impossible to machine blind. Tolerances were close and exceptionally clean internal surfaces were a necessity. Shell cores, as illustrated, were used in a green sand mold. The system was streamlined and the more compact unit did not hamper the mechanism. Costs were reduced to a fraction of the alternate composite machined assembly.

Unitcastings can possibly meet your unusual problems, too. Why not investigate today . . . call for a Unitcast Sales Engineer.

UNITCAST CORPORATION, Toledo 9, Ohio
In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

and discussions on subjects pertaining to research and standards for materials are covered. Typical topics include mechanical properties of various alloys, magnetic properties, hardness testing, and crack propagation in cold-rolled aluminum sheet.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 161112. Factors Controlling Resistance to Deformation and Mechanical Failure in Polycrystalline (Glass-Free) Ceramics. By J. B. Wachtman Jr., W. E. Tefft, D. G. Lam Jr., and R. P. Stinchfield, all from National Bureau of Standards; 83 pages, 8¼ by 10¾ in., paperbound, stapled; $2.25 per copy.

Elastic moduli and internal friction of refractory oxide materials were studied. Six elastic constants of sapphire were measured. Results differed from previous values for four of these constants.

PB 161118. The Thermal Conductivity of Solids at High Temperatures—A Bibliography. By W. T. K. Johnson, Diamond Ordnance Fuze Laboratories; 72 pages, 8 by 10½ in., paperbound, stapled; $2.00 per copy.

This alphabetical presentation of the literature on thermal conductivity of solids emphasizes measurement techniques at high temperatures. References are divided into 308 listings of publications issued since 1940. Each listing is accompanied by a brief abstract. Another 166 references to papers published prior to 1940 are appended without comment.

PB 161143. Evaluation of B. F. Goodrich 450 F Ambient Temperature Brake. By Carlos F. Afanador, B. F. Goodrich Aviation Products; 20 pages, 8¼ by 10¾ in., paperbound, stapled; $1.00 per copy.

A B. F. Goodrich capsule-actuated disc brake operating from a 450 F ambient temperature was tested, and effects of forced-air cooling were determined. Results of tests are discussed.

PB 161156. The Influence of Sheet Thickness on Tensile Properties of Metal Sheet. By Alfred Rudnick and Robert L. Carlson, Battelle Memorial Institute; 19 pages, 8½ by 11 in., paperbound, stapled; $0.50 per copy.

Relationship of cross-sectional area to total elongation in a wide range of alloys and various materials is presented. Included are aluminum alloys, mild steel, annealed copper, and soft annealed brass.

PB 161159. Elevated-Temperature Mechanical Properties and Oxidation Resistance of Columbium and Its Alloys. By F. R. Schwartzberg and W. D. Klopp, Battelle Memorial Institute; 10 pages, 8½ by 11 in., paperbound, stapled; $0.50 per copy.

Tensile strength and yield strength of columbium and its alloys at temperatures varying from 80 F to 2600 F are presented. Also, oxidation resistance at temperatures up to 1200 C for periods up to 20 hr is discussed.

PB 161169. The Availability and Properties of Rhenium. By Daniel J. Maykuth, Battelle Memorial Institute; 12 pages, 8½ by 11 in., paperbound, stapled; $0.50 per copy.

Mechanical and physical properties of rhenium are compared with tungsten and molybdenum. Applications and availability of rhenium are discussed.

PB 161182. Physical and Mechanical Properties of Tantalum. By H. R. Ogden, Battelle Memorial Institute; 16 pages, 8½ by 11 in., paperbound, stapled; $0.50 per copy.

Physical and mechanical properties of tantalum at temperatures varying from room temperature to about 3000 C are presented. Included are tensile, creep, expansion, and general physical properties.

PB 161330. A Bibliography on Acoustic Sources and Their Related Fields. By G. B. Thurston and R. Stern, University of Michigan; 68 pages, 8 by 10½ in., paperbound, side-stapled; $1.75 per copy.

Material on acoustic sources and related fields is outlined, and divided into single sources and receivers, arrays of sources and receivers, transducer properties, and acoustic fields. References listed cover the period from 1935 through 1958.

Circle 565 on Page 19

B.F.Goodrich

Concealed RIVNUTS® make air conditioner a snap to service

RIVNUTS help achieve the compactness and convenience featured by the makers of this room air conditioner, Drayer-Hanson Div. of Crane Co., Los Angeles.

The smooth appearance is not interrupted by visible fasteners. Concealed RIVNUTS under the bottom panel permit fastening panel to frame with wingnuts. Thus fan assembly and controls are accessible without use of tools. RIVNUTS in the base of the unit accommodate leveling bolts, which facilitate installation.

RIVNUTS are ideal for providing an adequate number of screw threads in thin sheet metal applications like this. At least six threads are available, to assure a sturdy attachment. RIVNUTS can be installed by one person, from one side of the work, in a few seconds with a heading tool.

If you'd like recommendations on a specific fastening problem, please send a print of your part.

You can improve fastening in sheet metal, tubing, tanks with RIVNUTS

New data booklet describes principle, typical applications of RIVNUTS, lists size and tool data. For free copy write Dept. MD-7, *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.*

See Sweet's Product Design File

B.F.Goodrich Rivnuts

Circle 566 on Page 19

SPEED PRODUCTION and LOWER COST on your products with this GRIP-NUT family of GRIPCO FASTENERS

GRIPCO LOCK NUT
One piece all metal.

GRIPCO CENTERLOCK NUT
Locking feature in the center for fast feeding. Can be applied from either end.

GRIPCO CLINCH NUT
With or without Gripco Lock. For application to metal too thin to thread or for inaccessible assemblies. Hex collar prevents turning when torqueing bolt.

GRIPCO PILOT-PROJECTION WELD NUT
With or without Gripco Lock. Centering collar positions nut and protects threads from weld spatter.

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With or without Gripco Lock. Countersink protects threads from weld spatter.

All types and sizes of Gripco fasteners listed in catalogue are available for immediate delivery.

Qualified fastener engineers are available for consultation on all your assembly problems.

Other Gripco Products:

- BRASS GRIPCO OR CENTERLOCK NUTS.
- MINIATURE WELD AND CLINCH NUTS, WITH OR WITHOUT LOCK.
- GRIPCO AND CENTERLOCK HI NUTS.
- STANDARD SEMI-FINISH FULL AND JAM NUTS.
- STAINLESS STEEL LOCK, WELD AND SEMI-FINISH NUTS.
- COLD FORMED SPECIAL NUTS OR PARTS TO PRINT.

The Nation's Oldest Manufacturer of Lock Nuts

Send for samples and NEW CATALOG today

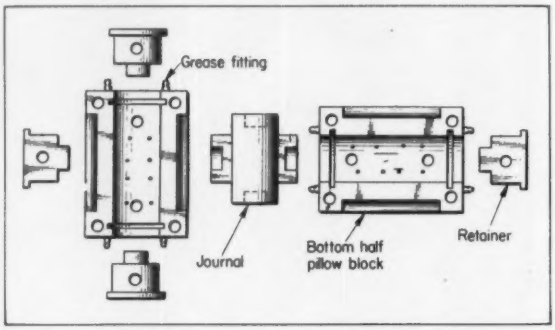
GRIP-NUT COMPANY

103 MAPLE AVE. ★ SOUTH WHITLEY, INDIANA

NOTEWORTHY Patents

High-Thrust Gimbal

Half cylinders welded together in a cross form the journal of a gimbal assembly. The pillow blocks are also semicircular. Bolts through the retainers and the

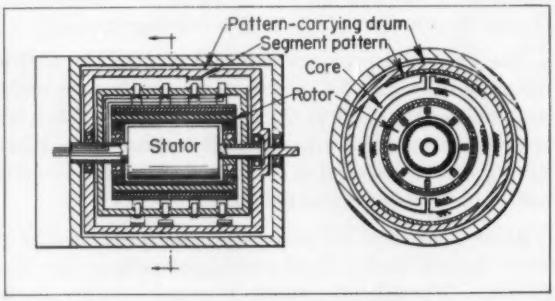


half pillow blocks hold the assembly together. Angular movement takes place between each half journal and its encircling half pillow block. *Patent* 2,938,459 *assigned to North American Aviation Inc., by Bernard R. McGraw and James E. Robertson.*

Analog-to-Digital Transducer

Binary-coded representation of the position of a movable member, such as a shaft, is achieved electromagnetically. One voltage from a number of alternating-current voltages corresponds to each binary digit.

The motor rotor has an external nonmagnetic shield. The shield is coated with a recording medium that can be magnetized along axially-spaced circumferential



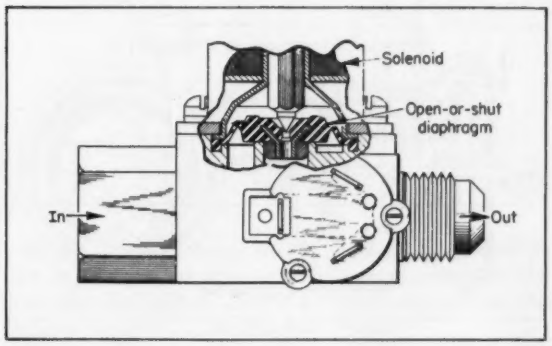
paths, one for each magnetic-pickup. Each pickup has a laminated core of magnetic material, two air gaps, and a winding around the core. These pickups are stationary. They are mounted adjacent to the magnetized coatings carried by the motor-rotor shield. When the stator is energized, signals of different intensity are induced in the pickup windings in accord

with the angular relationships of the magnetized coatings to the air gaps.

Radially outward of the pickup devices are segment patterns of magnetic material. These pattern segments are carried by a drum, which defines shaft position. For a certain drum position, the magnetic path afforded by a corresponding core, drum segment, and magnetized segment on the rotor induces a definite signal in the pickup. *Patent* 2,938,198 *assigned to United Aircraft Corp., East Hartford, Conn. by Nelson Berman and Sheldon Girsch.*

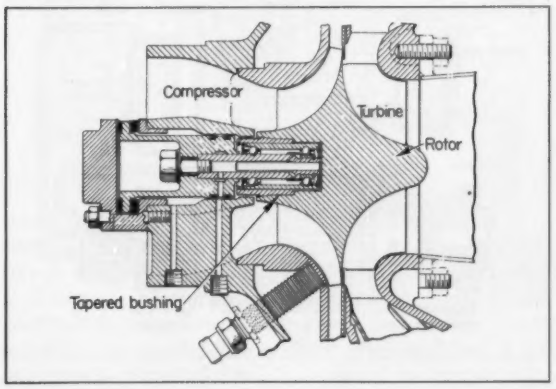
Pressure-Operated Electrically-Controlled Valve

Electrically-controlled hydraulic valve uses two diaphragm-type assemblies. The one shown is operated by a solenoid to open and shut off the flow of fluid. The second responds to fluid flow in the discharge line. Any pressure caused by a predetermined minimum, or



greater, flow deflects a leaf spring to close a switch in the solenoid circuit. If the flow is less than this minimum, the switch opens, the solenoid is de-energized, and flow is shut off completely. *Patent* 2,939,927 *assigned to the Dole Valve Co., Chicago, by James A. Kozel, Victor E. Rimsha, and Richard H. Powell.*

High-Speed Turbo-Compressor Bearing



Concentricity of a turbo-compressor rotor and an outer ball-bearing race is maintained under severe conditions of differential expansion by a tapered bushing. When the rotor is at rest, a heavy shrink fit prevails

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There are 3 simple checks to be sure that the blowers you design into your product are right. Certainly, a blower should last the life of the equipment. It should deliver rated capacity. And it should be compact, trouble-free and efficient.

Buffalo, experienced builder of every type of fan for both Original Equipment and for major air handling systems, has designed this "Q" Factor* of Quality into every fan bearing the name. For this reason, a Buffalo Fan, designed for the job, is your assurance of superb, worry-free performance in the air-moving function of your equipment.

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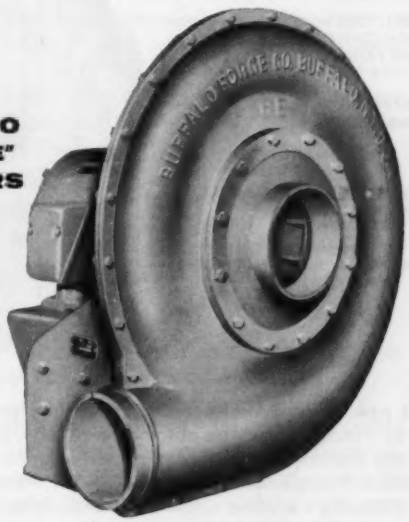

For medium-volume, medium-pressure applications, there is no better buy than "E" Blowers. Husky housings, interchangeable for clockwise or counter-clockwise rotation. Wheels available in Cast Iron, Stainless, Everdur, Brass or Aluminum. Capacities to 5500 cfm; pressures to 1¾ psi. Compact, direct-connected arrangement for best installation. Write for Bulletin FI-410 and judge for yourself.

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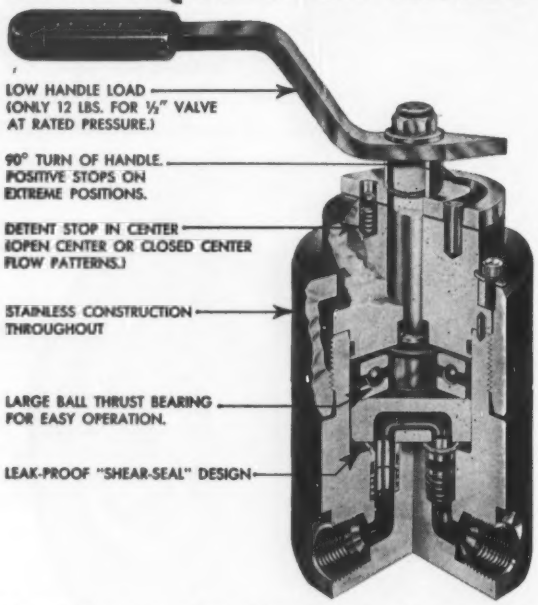
10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES


LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
90° TURN OF HANDLE. POSITIVE STOPS ON EXTREME POSITIONS.
DETENT STOP IN CENTER (OPEN CENTER OR CLOSED CENTER FLOW PATTERNS.)
STAINLESS CONSTRUCTION THROUGHOUT
LARGE BALL THRUST BEARING FOR EASY OPERATION.
LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

Write for Catalog 59-60

CONTROL VALVE DIVISION

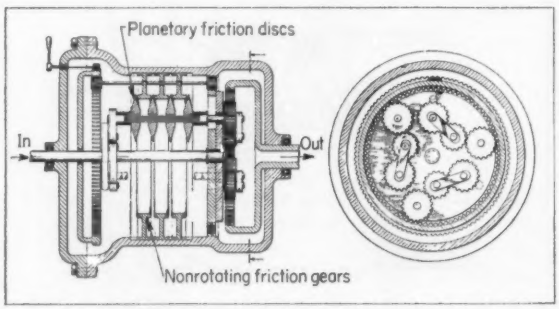
Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

locally between the rotor bore and the tapered bushing at the central periphery of the taper and midway between the balls. This fit and the bushing taper cause tension stresses in the outboard rim of the rotor hub, as well as high compressive stresses where the interference fit is greatest. Both ends of the bushing are essentially unstressed. At high rotor speeds—of the order of 60,000 to 110,000 rpm—the rotor hub expands not only under centrifugal force but also because of heat. The taper bushing adjusts itself to maintain stable compressive contacts with both the rotor bore and the outer bearing race. *Patent* 2,939,626 *assigned to De Laval Steam Turbine Co., Trenton, N. J. by Rudolph Birmann.*

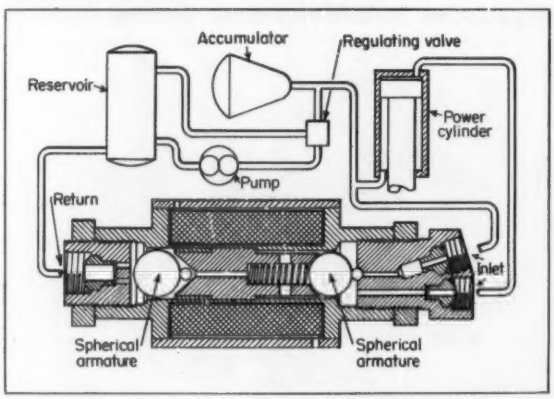
Adjustable-Speed Drive

Nonrotating friction rings in a planetary arrangement provide changes of speed in small steps. There are three sets of cone-shaped planet discs. These discs are pivot



mounted on the input arm or spider of the planetary train. They are adjusted inward and outward to change speed ratio. Each set of friction discs is spring-loaded axially against alternate friction rings. The rings can move axially only. *Patent* 2,939,345 *assigned to Curtiss-Wright Corp. by William E. Burns.*

Sequential-Operation Solenoid Valve

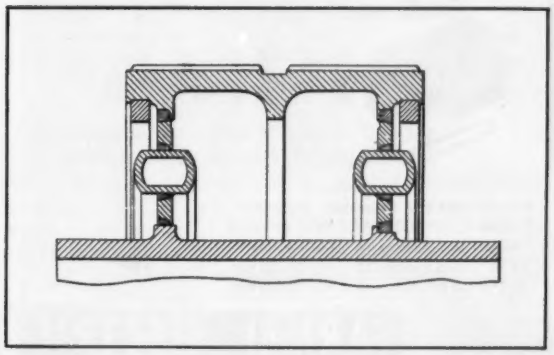


Energized by a solenoid, two spherical armatures at opposite ends of the coil respond in different times because of unequal magnetic-shunt sections. Thus, one spherical armature closes the outlet port (left) of the valve before the other spherical armature (right) opens

the inlet port. When the inlet port is open, the unit pressures on both sides of the power piston are equal and the piston, which has unequal pressure areas, moves downward. When the coil is de-energized, the inlet port closes before the outlet port opens. *Patent* 2,935,091 *assigned to Bendix Aviation Corp., South Bend, Ind. by Franklin O. Wisman.*

Sound Damping Gear

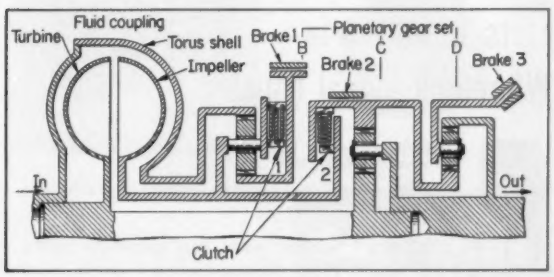
Noise from contacting gear teeth is intercepted and dissipated by a gear web of composite construction. Hollow toroidal-shaped members are welded into the



web. Thickness of metal in the walls of the toroids is thin in comparison with web thickness to improve the noise damping effect. *Patent* 2,939,331 *assigned to the General Electric Co., by Frank E. Weeks.*

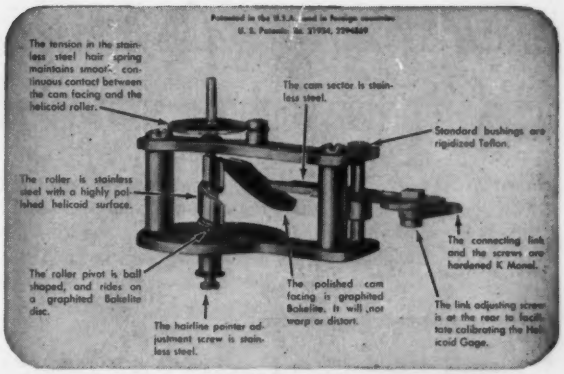
Six-Speed Transmission

Three planetary gear sets, a fluid coupling, three brakes, and two clutches provide a six-speed transmission. Direct drive by the torus shell takes place



when both clutches are engaged. In addition, five varying reduction ratios are obtained by engaging different combinations of clutches 1 and 2 and brakes 1, 2, and 3. Maximum reduction ratio is given by the combination engagement of brakes 1 and 2. The transmission is in neutral when all clutches and brakes are disengaged. *Patent* 2,939,341, *assigned to General Motors Corp., Detroit, by Harold I. F. Evernden.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.


The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
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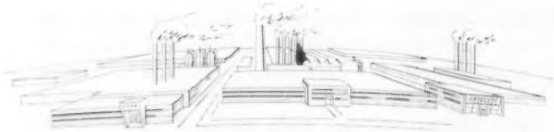

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NOW: A one-piece Paramount aluminum die casting with pieces cast integral.

BEFORE: A six-piece welded steel bracket for holding signal mechanism.

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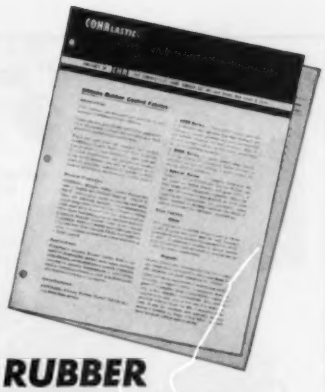

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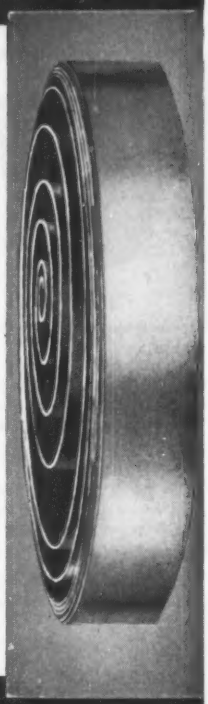

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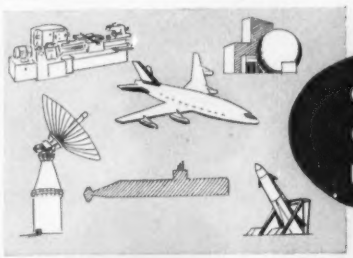

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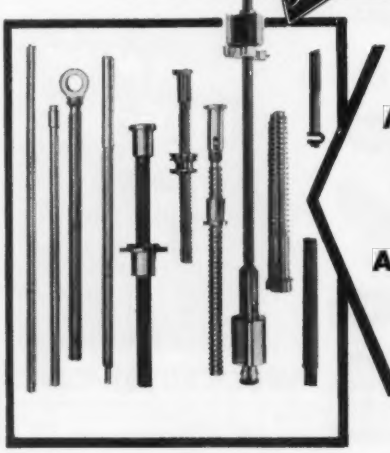

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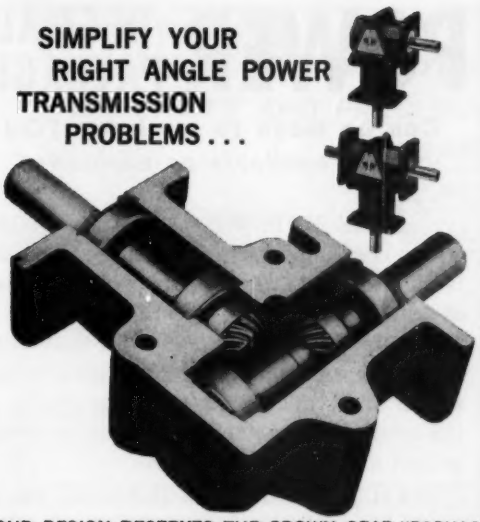

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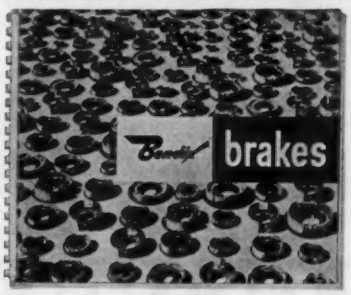

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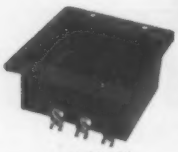

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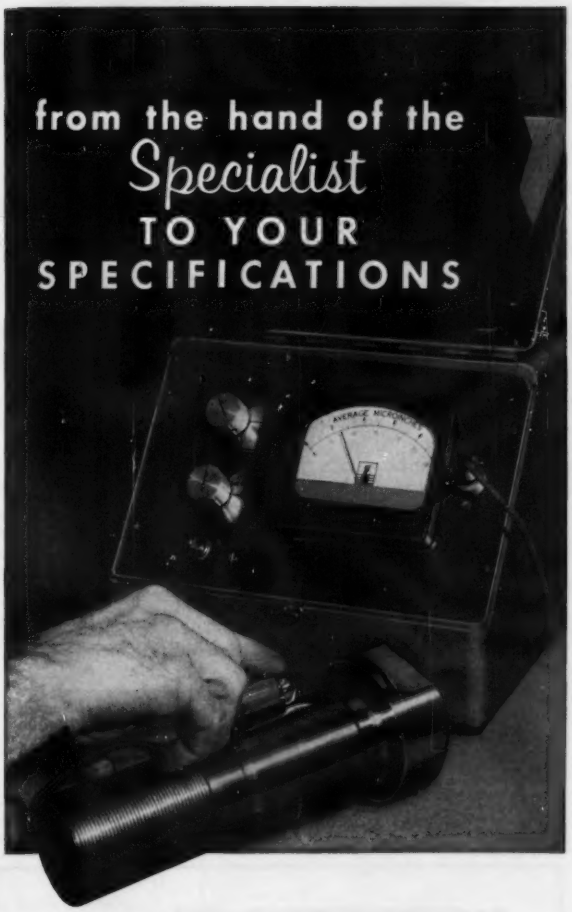

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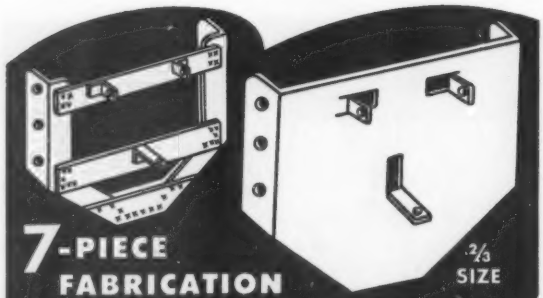

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BPA NBP

backtalk—

—Editor No. 19

Samuel E. Barnes, who "vas in Zinzinnati" before coming to Cleveland, migrated from General Electric Co. (at Evendale) to become an assistant editor of MACHINE DESIGN. At GE, he worked on the aircraft nuclear propulsion

project, designed training aids, and taught classes in jet-engine design. His last assignment was the preparation of engine handbooks. Before and during the early part of his engineering career, Sam studied at the University of Cincinnati's day and evening colleges and under GE's training program. He is a Registered Professional Engineer and belongs to the American Rocket Society.

Despite his benign countenance, Sam apparently has a highly competitive nature: His outside interests include archery; guns, which he collects and uses for hunting; and the practice of judo. Always looking for something new to do, he is now taking flying lessons.

—AC Equals Air Current

The editors of MACHINE DESIGN take vacations from their work just like everybody else, but—as is the case with most engineers—their interest in things mechanical never quite shuts down. So it was that Jim Parks, visiting a typical Amish village near Lancaster, Pa., found a truly unique machine shop. It was in a furniture-maker's establishment, where the owner had an impressive array of power equipment—lathe, drill press, jointer, router, sanders.

You would naturally expect to find such machinery in a furniture factory, but you would also normally find each of these devices plugged into an electric outlet. Not so in the Amishman's shop—Mother Nature supplies his power. Each tool is driven by a belt which is turned by a huge lineshaft; the shaft receives power from a windmill behind the building. The result of this incongruous blending of old and new? "Some of the most beautiful early American furniture I've ever seen," says Jim.

—Praise Paraphrased

All of us have had at least one experience with hiring—or being hired—and are therefore familiar with the Job Reference. In an article in American Management Association's *Management Review*, Rawle Deland says that a company that doesn't adequately check references stands a 50 per cent chance of hiring the wrong man. Mr. Deland also points out that it can be dangerous for a prospective employer to believe everything he hears from a reference giver—apparently the very absence of a former employee tends to make him look better than he ever did on the job. Here, from the July *Management Review*, are selections from a "pocket translator" for interpreting the more exuberant references.

The Embellished Words	Their Bare Meaning
He's a consistently good team worker.	Hasn't had an original thought in 20 years.
He's always staunch in supporting his superiors' recommendations.	A yes man.
A strong speaker who really *sells* his ideas.	Big mouth.
Conscientious? I can't tell you how many times I've seen him take work home nights or on weekends.	He can't get organized.
He's at his best when handling the broad outlines of a situation and delegating the details.	He can't add.
A great believer in face-to-face communications, rather than memos and reports.	He can't spell.
He had good command of the job, considering his age.	Too young to cut the mustard.
I'm sure you'll find him capable of handling *any* job you have in mind.	We're glad to get rid of him.

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TYPE 620 Elapsed Time Indicator (top) shown approximately full scale, is offered for operation on 115 volt, 60 or 400 cycle power. Dimensionally, the version illustrated meets MS-28053 and NEMA standards, and is front-panel mounted through a 1-19/32" diameter opening. All relevant test requirements of MIL-M-7793B and MIL-E-5272B are met or exceeded (to 50 G's shock, 2000 cycle vibration). An optional back-panel mounting adapts to existing panel drilling. Hermetically sealed, Type 620 has recessed solder lugs at rear for electrical connections. Total registration 9,999.99 hours, weight about 4 ounces. Designed primarily for military use, the unit will give unsurpassed service in rugged industrial applications.

TYPE 120 Miniature AC Motor (right) is rated 115 volts, 60 cycles. Permanent-magnet design assures fast response and truly synchronous operation. Running torque .08 inch ounce at 240 rpm rotor speed, weight approximately 2 ounces.

TYPE 821 Ungoverned DC Motor (bottom) for no-load speeds from 8,000 to 20,000 rpm. Typical 28-volt armature develops 14,200 rpm no-load, 12,600 rpm at 0.1 inch ounce load, with current drain about 100 ma. Weight under 2 ounces. Meets MIL-T-5422E.

TYPE 890 115-Volt 400-Cycle Motor (left) is a single-phase hysteresis-synchronous motor. Available as basic ⅞" motor (like Type 120 at right), or in 1-inch flange-mounted can illustrated, containing motor and capacitor network. Produces .01 inch ounce torque at 3000 rpm. Weight under 2 ounces.

Write for complete information, specifications.

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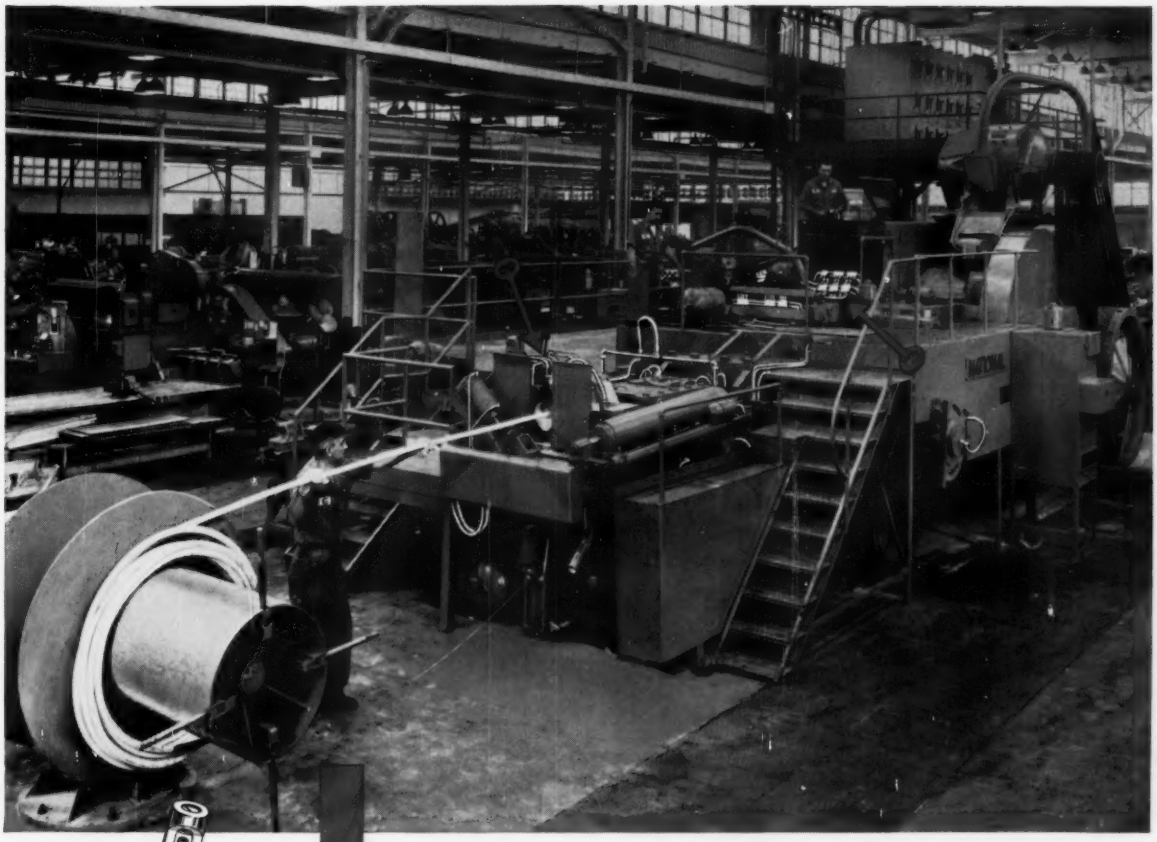

FARVAL—Studies in Centralized Lubrication No. 238

Farval automatically lubricates 138 bearings on world's largest Boltmaker

It's a 1¼-inch cold forger, designed and built by National Machinery Co. for the Cleveland Cap Screw Co., Cleveland, Ohio. This versatile machine automatically produces hex head cap screws. It draws steel rod to wire size, cuts it to proper length, extrudes the blank, heads, trims the head, points the end and then rolls on threads, all this at the rate of 38 complete screws per minute.

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Write for revised Bulletin 26-T, which shows how Farval can extend both bearing and gear life on new machinery—as well as on older equipment now in use.

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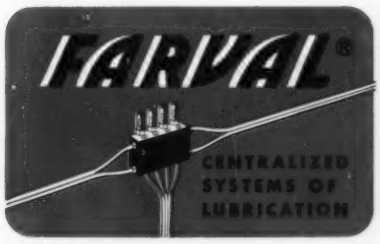

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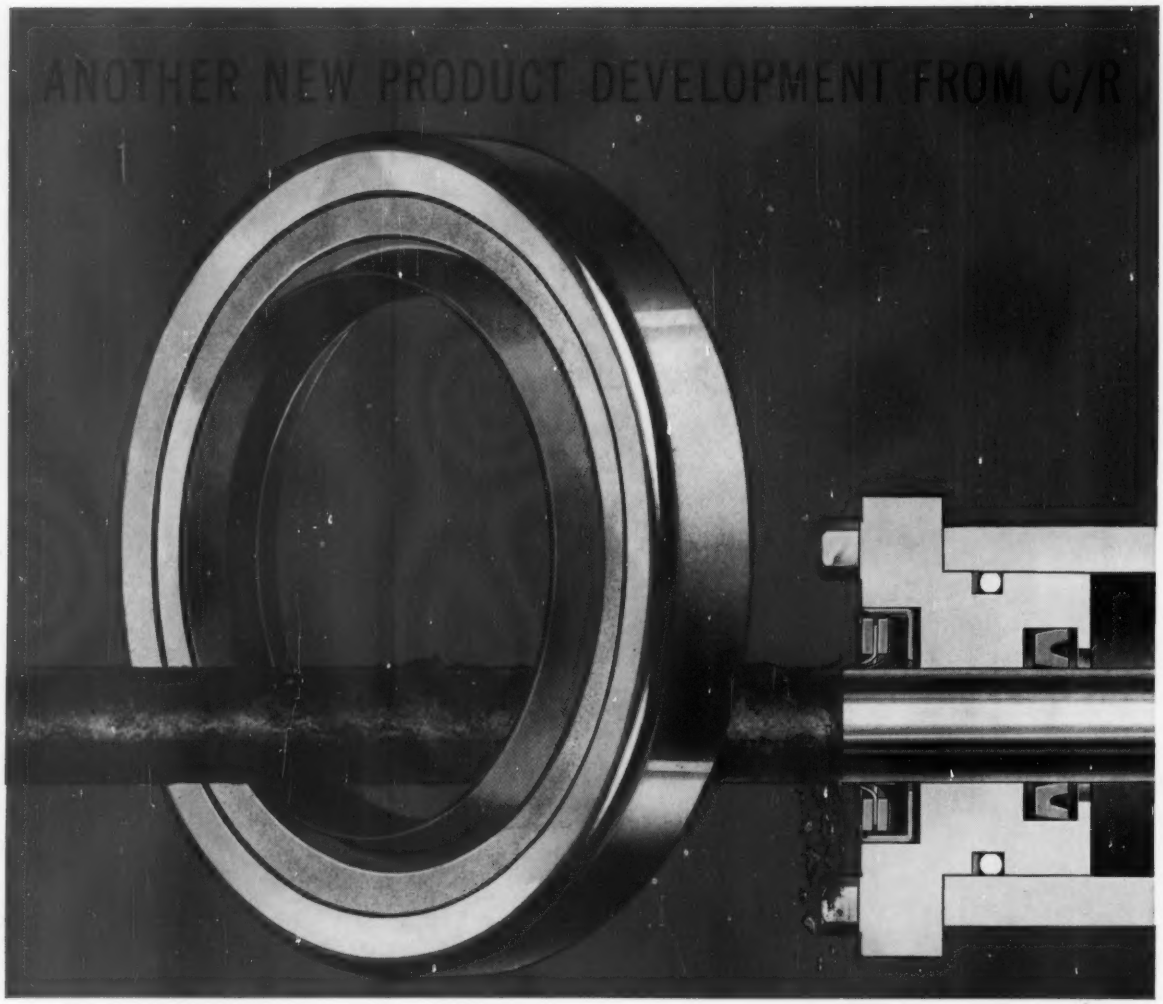

New Wiper-Scraper Seal for Cylinders

Scrapes off ice, mud, tar – wipes off water, dust, other contaminants

Now, you can effectively exclude dirt and other contaminants from hydraulic cylinders under the most severe field conditions. One compact unit, the C/R SC Wiper-Scraper Seal does the job. Formerly, a separate rod scraper had to be installed in front of the ordinary wiper seal. The special machining necessary, plus the scraper ring, and retaining ring made this an expensive installation.

Chicago Rawhide's SC Wiper-Scraper Seal combines a spring brass scraper and synthetic rubber wiping member in one steel shell. The I.D. of the scraper is slightly under shaft size to provide a snug fit that will remove tar or frozen mud, but it has sufficient play within the shell to tolerate any off-center conditions of the rod such as caused by bearing "bore-slop." The cost is much lower than any other combination of scraper and wiper. "Design-in" cost is low, assembly simple. Most important is the performance contribution to the cylinder. The additional value of longer packing life and increased operating dependability with the SC Wiper-Scraper Seal will far outweigh the nominal cost.

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